4

Gulf of Cadiz Expedition
Contribution Number 1

The Gulf of Cadiz Expedition: R/V *Oceanus* Cruise 202

by
Maureen A. Kennelly
John H. Dunlap
Thomas B. Sanford
Eric L. Kunze
Mark D. Prater
Robert G. Drever

Technical Report
APL-UW TR 8914
April 1989

Contract N00014-87-K-0004

Gulf of Cadiz Expedition
Contribution Number 1

The Gulf of Cadiz Expedition: R/V *Oceanus* Cruise 202

by
Maureen A. Kennelly
John H. Dunlap
Thomas B. Sanford
Eric L. Kunze
Mark D. Prater
Robert G. Drever

Technical Report
APL-UW TR 8914
April 1989

Applied Physics Laboratory University of Washington
Seattle, Washington 98105-6698

Contract N00014-87-K-0004

Acknowledgments

We gratefully thank Captains Howland and Palmieri and all the ship's personnel aboard R/V Oceanus *for their cooperation and competence. We thank Barrie Walden, Alden Cook, and Lenny Boutin of WHOI for their promptness in getting the ADCP repaired. We also acknowledge Marv Stalcup of WHOI for designing and constructing the radar transponder mooring and running the replicate salinity samples. Paul Stevens of the Fleet Numerical Oceanography Center provided the T-6 XBTs. This work was funded by the Office of Naval Research under Contract No. N00014-87-K-0004.*

ABSTRACT

Velocity, hydrographic, and dissipation measurements were made during the Gulf of Cadiz Expedition, 4–28 September 1988, to observe the vortices shed in the wake of Ampere Seamount, to survey eddies formed by the Mediterranean outflow near Cape St. Vincent, and to study the structure and dynamics of the outflow plume west of the Strait of Gibraltar. The expedition, the instrument systems, and their deployments are described, and preliminary results are presented.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

This report describes the Gulf of Cadiz Expedition aboard R/V *Oceanus* and the instrument systems used, summarizes the instrument deployments made during the cruise, and presents some preliminary results. The objectives of the expedition were to observe the vortices shed in the wake of Ampere Seamount, to survey eddies (Meddies) formed by the Mediterranean outflow near Cape St. Vincent, and to study the structure and dynamics of the outflow plume west of the Strait of Gibraltar. The cruise consisted of two legs: leg 1, from 4–19 September 1988, corresponded to leg IV of *Oceanus* voyage 202 and leg 2, from 21–28 September 1988, corresponded to Leg V.

This scientific program was funded by the Office of Naval Research and was under the direction of four Principal Investigators: T. Sanford and E. Kunze of the University of Washington, J. Price of the Woods Hole Oceanographic Institution, and R. Lueck of Johns Hopkins University. The operational areas for the expedition included Ampere Seamount, the area around Cape St. Vincent, Portugal, and the Gulf of Cadiz west of the Strait of Gibraltar (Figure 1).

During the first leg, measurements were made on the flanks of Ampere Seamount (35°03'N, 12°52'W) to examine the fine-scale potential vorticity field, which is postulated to exist on the same scales as internal waves. The likelihood of finding fine-scale vortices was thought to be greater in the wake of a seamount. Four drifters, drogued to track water between 100 and 300 m depth, were deployed to determine the structure of the mean flow. They revealed an east-southeast flow of approximately 6 cm s^{-1} on the north flank of the seamount and a stagnation point to the southeast. Two surveys were conducted with expendable current profilers (XCPs) in search of eddies shed in the wake of the seamount. Each survey was a cross pattern. The first was 4 × 7 km, and the second was 9 × 7 km. By combining horizontal temperature and velocity gradients, it will be possible to estimate potential vorticity. Anomalies in potential vorticity are an irrefutable signature of shed vortices since internal waves have no potential vorticity signal.

Another purpose of the first leg was an extensive survey of the slope and the deep water regions southwest of Portugal to observe forming and newly formed Meddies. Eddies containing cores of Mediterranean water often have been observed in the

Sargasso Sea (McDowell and Rossby, 1978) and Canary Basin (Armi and Zenk, 1984; Armi et al., 1988) and may be an important mode for the movement of Mediterranean water into the Atlantic. One Meddy was surveyed extensively. The core of this Meddy was in near-solid-body rotation out to 8 km radius.

The second leg of the expedition was devoted to measuring the structure and modifications of the Mediterranean water as it exits the Strait of Gibraltar and flows down the steep channels leading into the Gulf of Cadiz. These observations will be used to determine characteristics of the outflow plume as a function of distance from the strait, and to evaluate a model developed by Jim Price for such flows.

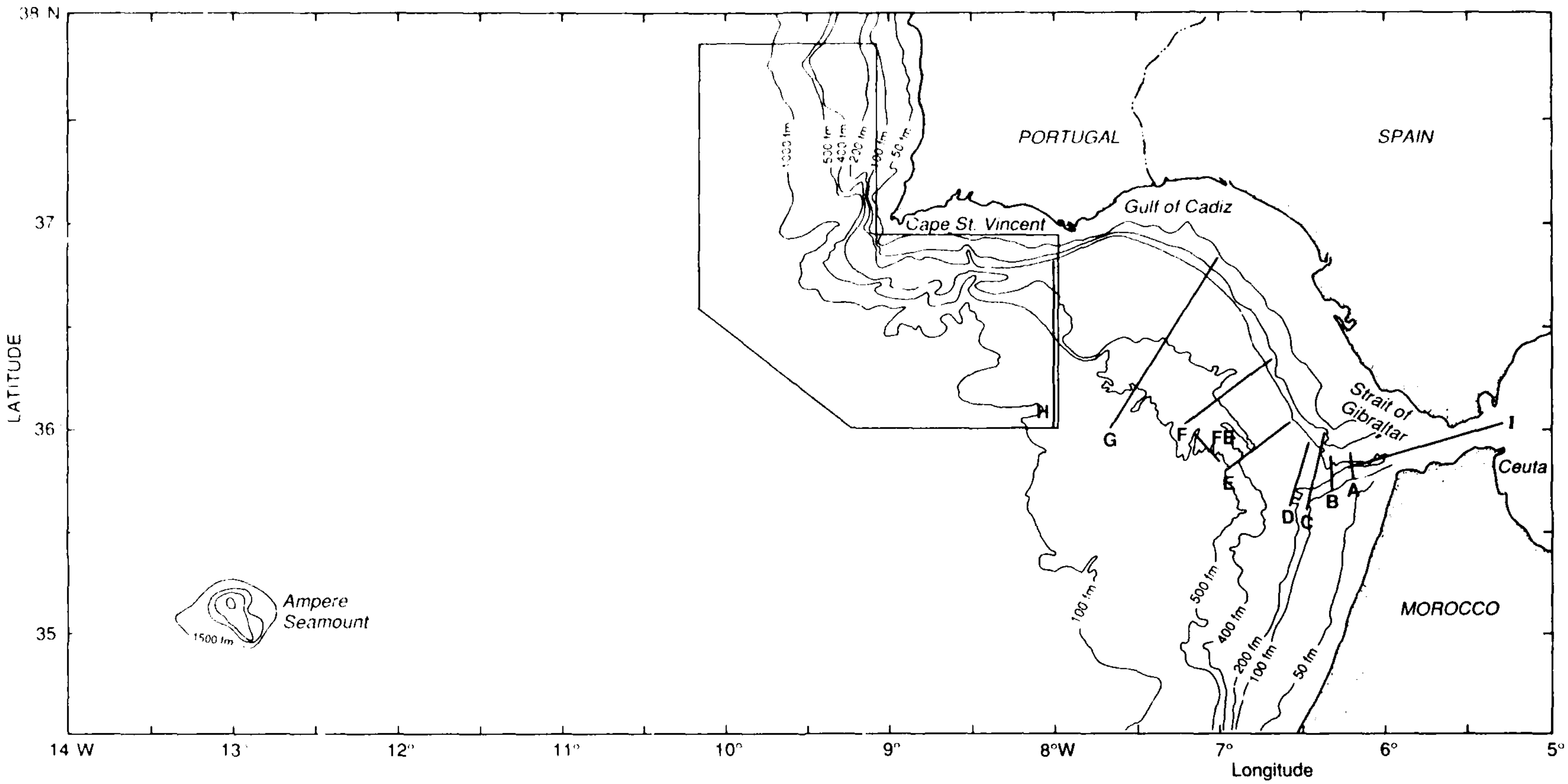

Figure 1. Operational areas for the Gulf of Cadiz Expedition. The areas included Ampere Seamount, the Cape St. Vincent region (boxed), and the continental slope west of the Strait of Gibraltar (sections A–I).

2. INSTRUMENT SYSTEMS

Various instrument systems were used throughout the cruise. Much of the field work during leg 1 was conducted with expendable profiling devices while the vessel was under way. These included expendable bathythermographs (XBTs), expendable current profilers (XCPs), and expendable sound velocity profilers (XSVs). Additional instrument systems included a moored radar transponder, drifters, a conductivity-temperature-depth (CTD) profiler, an acoustic Doppler current profiler (ADCP), a bottom depth recorder, a serial ASCII instrumentation loop (SAIL), and navigation equipment. These instrument systems were supplemented with expendable dissipation profilers (XDPs) on leg 2.

2.1 Mooring

A radar transponder was moored atop Ampere Seamount (which is at a depth of approximately 50 m) to aid navigation during the seamount component of the experiment. The mooring was designed by Marv Stalcup of the Woods Hole Oceanographic Institution and consisted of a tethered float and an anchored float (Figure 2). These two floats were connected by 20 ft of polypropylene line. Attached to the free float were a radar transponder, light, battery pack, retrieval line with a small float, and ballast weights. A 350-lb anchor made of steamer chain was attached to the second float by 100 m of plastic-covered steel cable and pear links.

The tethered float was top heavy when initially deployed, so 90 lb of lead were added to the bottom. The anchored float was also top heavy, but no additional weight was available so it floated on its side rather than upright. The batteries in the radar transponder were replaced after 72 hours of deployment. Unfortunately, the second battery pack flooded shortly thereafter.

2.2 Drifters

Four drifting buoys (drifters) were deployed in the vicinity of Ampere Seamount and tracked to determine the mean flow around the seamount. The drifters were designed by Robert Drever of APL-UW. Their design was simple in concept, as shown in Figure 3. They were composed of an OAR Inc. xenon flasher, a radar reflector, a Polyform float, a small float with a tag line for recovery, lead ballast weights, nylon and Dacron

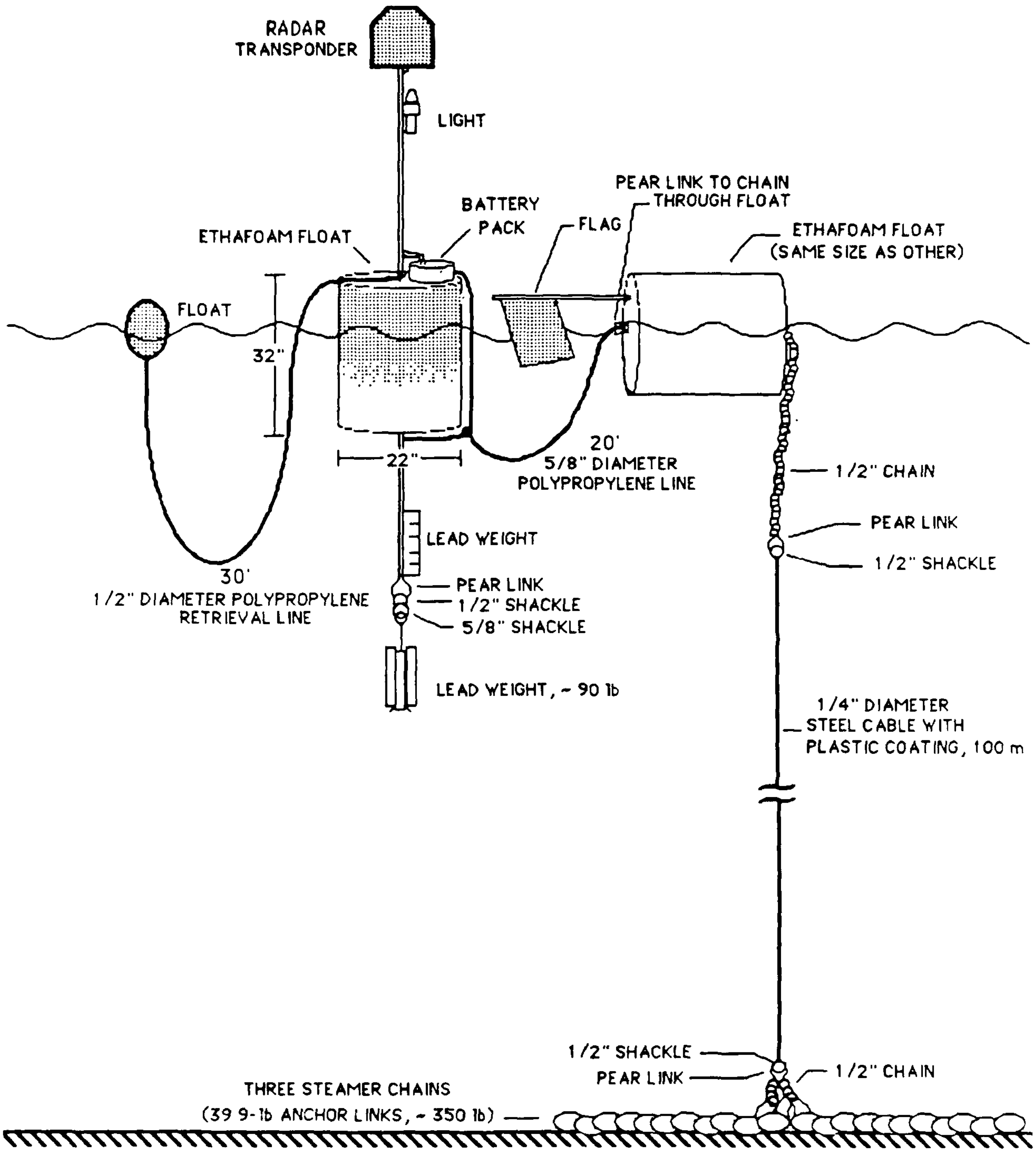

Figure 2. Radar transponder mooring on summit of Ampere Seamount.

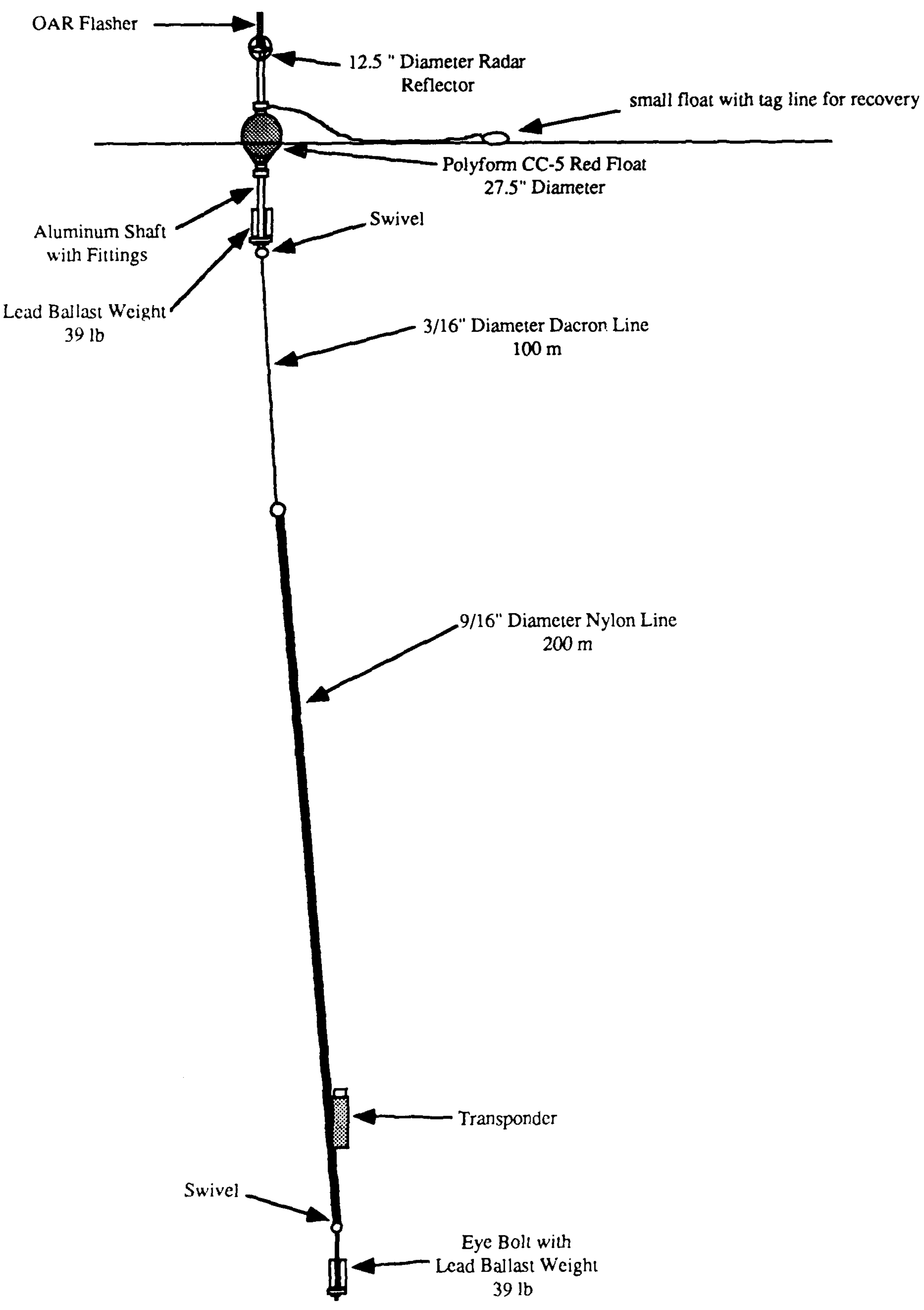

Figure 3. Drifter design.

line, and either an Oceanographic Instrument Systems Inc. transponder or an acoustic command receiver/transponder/timer. The acoustic command receivers were used only in the transpond mode.

The drifters were designed to have low drag in the first 100 m and high drag between 100 and 300 m to track the flow below the seamount summit. XCP profile data from *Meteor* Cruise 57 in 1981 for the area in which the drifters were going to be used showed that most of the high current structure was in the upper 50 m. Below 50 m the current was less than 15 cm s^{-1}. The largest drag force would be on the 200 m of 9/16-in. nylon, causing the drifters to track the water in the 100 to 300 m depth range. The transponders were used to track the drifters acoustically from the ship, using the standard 12-kHz depth sounder. The drifters each had a separate acoustic signature. The depth recorder was run at a 4-s repetition rate; the two transponders would reply once every 4 s, and the command receivers/transponders would reply once every 8 s because of a built-in circuit that set their fastest reply rate to 8 s. The pulse duration was set to about 12.5 ms for one transponder and one command receiver and to about 25 ms for the other two units. The range was limited to a few kilometers because of the strong decrease in sound speed in the upper thermocline. The radar reflectors on the drifters were painted in different color combinations to aid in visual identification. Table 1 summarizes the drifter characteristics.

Table 1. Drifter characteristics.

Drifter No.	Serial No.	Model No.	Type	Transmit Pulse (ms)	Markings
1	2419	2000	Transponder	25	Orange
2	2392	3000	Command Receiver	12.5	Orange/black
3	2393	3000	Command Receiver	25	Orange/green
4	2418	2000	Transponder	12.5	Orange/white

The drifters served our purposes well, but the limited radar range due to sea-surface backscatter and the short acoustic range (<2 km) constrained their use to relatively small-scale experiments where their positions could be monitored regularly by ship. It might have helped to have something like an AMF Inc. acoustic command system that would have been more omnidirectional than the ship's narrowbeam depth recorder. A

transponder that could have been lowered over the side would have also helped. There is a need for better gear to recover the drifters because of the small diameter of the line and the large drag as the ship pulls the drifters through the water.

2.3 XCP/XBT/XSV Acquisition System

XCP/XBT/XSV data were acquired in real time with a Hewlett Packard 9020 computer using an integrated acquisition program written in HP-Basic, which also provided real-time processing and display of the data. Data from up to three probes could be acquired and displayed simultaneously (with three co-running "partition" programs controlled by a fourth "master" program). Raw XBT and XSV data and processed XCP data were archived on floppy disk. In addition, as the data were acquired the complete raw data stream was saved on an HP9144 magnetic cartridge tape drive connected to the HP9020. Raw data from the XCPs, XBTs, and XSVs were stored along with a time stamp, an indication of the probe type, and the partition that acquired the data.

A schematic of the acquisition system is shown in Figure 4. There were four Sippican-manufactured MK-10 XCP signal processors, one for each of the four channels (10, 12, 14, and 16) of XCPs deployed.* At any time, only three MK-10s could be connected via GPIB cables to the three available I/O ports on the computer. Therefore the channel-10 MK-10 and channel-12 MK-10 were alternately attached to partition 1. The channel-14 MK-10 was always attached to partition 2, and the channel-16 MK-10 to partition 3. MK-9 XBT/XSV receivers were also connected to partitions 2 and 3 on the computer via GPIB cable.

In case of computer failure, the data were also stored on VHS audio/video magnetic tape. One backup system was dedicated to the XCP data and a second, independent system to the XBT/XSV data. Each backup system consisted of a VCR, a Sony Model PCM-F1 digital audio processor (PCM stands for pulse code modulation), and a power adapter. The frequency-modulated data from XCP channels 14 and 16 were stored

*MK-10 XCP signal processors used during Cruise 202:

Channel	Serial #	Local ID
10	844003	AMP
12	852601	EM2
14	844001	EM1
16	845103	Niiler

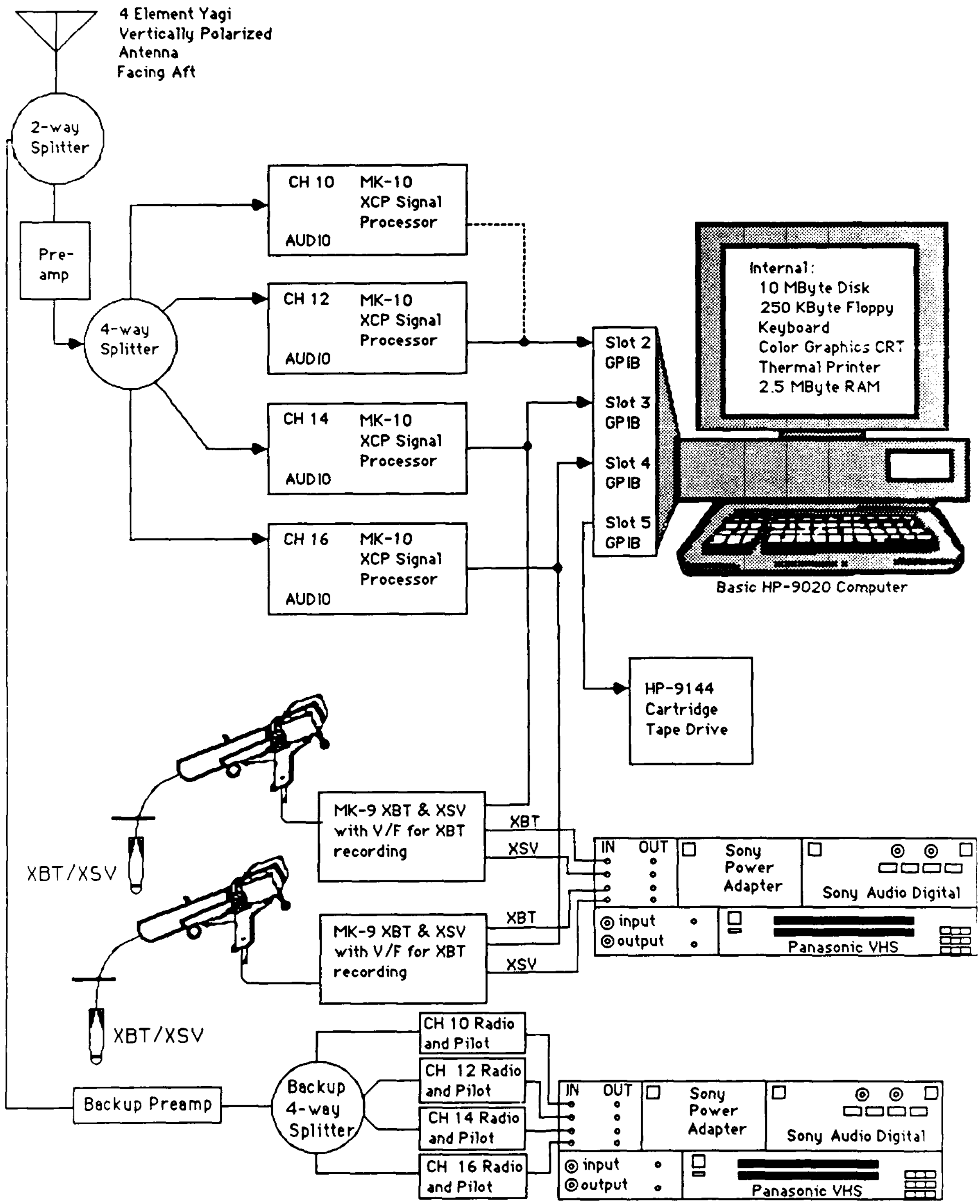

Figure 4. XCP/XBT/XSV acquisition system configuration.

directly on the audio tracks of the VHS tape. XCP data from channels 10 and 12 passed through the digital audio processor for storage on the video tracks.

The XBT and XSV data were recorded on VHS tape as four frequency-modulated (FM) signals. The XSV signals are FM signals to begin with. They need only to be amplified and filtered to be recorded. The XSV data were passed through a digital audio processor and stored on the video tracks of a VHS tape. The XBT output was an analog voltage that was converted to an FM signal. The frequency range of the XBT FM signal was selected to use the frequency range of the Air Deployed XBT (AXBT), so that with a little work the AXBT card in the MK-9 receiver could be used to play through the backup data if they were needed. (The standard AXBT output is an FM signal.) The converted, FM XBT data were stored on the two VHS audio tracks. Both MK-9s were modified to emit a frequency-modulated voltage for recording the XBTs on VHS tape.

2.3.1 XCP Drops

In all, 184 Sippican Inc. Mod 7 XCPs were launched. Four channels (10, 12, 14, and 16) were used during the cruise. The channel-10 XCPs were specially manufactured for this expedition. Appendix A gives the drop particulars.

Three aluminum Cushcraft four-element Yagi antennas were mounted on the *Oceanus* for XCP reception. The antennas were located facing aft on the main mast, facing starboard on the main mast, and facing forward on the catwalk between the stacks. All antennas were mounted with the elements vertical for vertical polarization. All the elements were located on one side of the aluminum mounting pipe in the direction of the antenna's directivity. RG-8 cable connected the antennas to the MK-10s.

Before deployment, each probe was tested for radio operation, probe operation (shown by the presence of the three audio frequencies), and compass-channel response to a moving magnet. The squib wires coming out the base of the electronics housing were also examined. Only one XCP failed the prelaunch check for radio operation and was not deployed.

Of the 184 XCPs deployed, 46 were on channel 10, 46 on channel 12, 45 on channel 14, and 47 on channel 16. The channel-16 probes had the poorest record with 11 failures, followed by channel 12 with 7 failures, channel 10 with 4 failures, and channel 14 with 2 failures. Two failure modes were channel specific: the wire broke early

only on channel-10 probes, and the compass coil area was half its expected value only on channel-14 probes. The other problems, excluding drops for which there were no good data at all, were electrode reversals, bad temperature data, and noisy data. The overall success rate for the XCPs was 87%, or 160 good drops.

2.3.2 XBT Drops

Three types of Sippican Inc. XBTs (T-5, T-6, and T-7), going to depths of 1830 m, 460 m, and 760 m, respectively, were used during the cruise. Launchers were located on both the starboard and port aft quarters of the ship. Each launcher was connected to a MK-9. In all, 229 XBTs were deployed. Appendix B gives the drop particulars.

Seven type T-6 probes were deployed during the cruise, and all provided good data. Forty T-7s were deployed, with a 90% success rate: two did not provide any good data and two did not provide data to full depth. The T-5 success rate was somewhat disappointing—82%, or 150 good drops out of 182. The failure modes for the T-5s were as follows: 13 yielded no good data, 13 did not provide data to full depth, 3 had obvious temperature offsets, 2 were noisy, and 1 contained temperature jumps.

2.3.3 XSV Drops

Two types of Sippican Inc. XSVs (XSV-02s and XSV-03s), going to depths of 2000 m and 850 m, respectively, were used during the cruise. The same launchers were used for the XSVs as for the XBTs. In all, 55 XSVs were deployed. Appendix C gives the drop particulars.

During the first few deployments, the XSVs would not process or display. It was observed that as an XSV-02 (slowfall type) was launched it neither started the MK-9 nor provided ac signals more than 10 mV. More solid grounds were placed on the MK-9; however, they did not seem to solve the problem. Next, the XSV boards were swapped between MK-9 units. The next XSV-02 (XSV 5) worked well, giving voltages of more than a volt.

However, the XSV failure problem recurred. Seldom were the proper prelaunch voltages measured from the MK-9 or usable signals received from the falling probes. The condition of the launcher and cables was repeatedly checked. For a while it was thought one or both of the XSV boards were damaged.

Closer examination of the XSVs revealed that the cannister was often improperly aligned with the shipboard spool. Evidently, the probes were assembled without regard to the notch on the cannister and the arrowhead on the spool. There are three connecting tabs on the cannister, allowing three different orientations between the cannister and spool. Because only one orientation permits the correct connections to be made at the launcher, the data return was poor. Seven probes failed before our discovery of the manufacturing error. The remaining probes were checked and realigned if necessary. The probes that were realigned are noted in Appendix C.

Of the 55 XSVs launched, 52 were type 02 and the remaining three were type 03. All the type 03s provided good data. The overall success rate for the type 02s was 79%. Before the manufacturing error was detected, seven of the first nine XSV-02s failed. After that, one failed to provide good data; another was noisy, and two did not provide data to full depth.

2.4 CTD Casts

A Sea-Bird Electronics (SBE) Model 9 underwater CTD unit, serial number 1, was used for this cruise. A 12-kHz pinger was attached to the frame of the unit and used for casts going to the bottom. Ninety-nine pounds of ballast were also attached to the frame.

The underwater unit was modified by SBE before the cruise to change the order of the data variables to match SBE's software.

The underwater unit contained the following sensors: a Paroscientific Digiquartz pressure sensor (model 76KB-036, serial number 18377) with a pressure range of 0 to 6000 psi, dual temperature sensors (model SBE-3-01F, serial numbers 574, primary, and 575, secondary), dual conductivity sensors (model SBE-4-01, serial numbers 166, primary, and 179, secondary), and a submersible pump (model SBE-5-01, serial number 1). The pump increased the flushing speed of water through both conductivity sensors to improve their dynamic response.

The CTD data-acquisition computer was a COMPAQ Deskpro 286 Personal Computer (Model 40, serial number 4809AM3B1351). A NEC Multisync II monitor was used with the computer. Boards installed in the computer included a VEGA brand enhanced graphics adapter (EGA) board, a National Instruments GPIB-PC-IIA board,

and an Intel 80287 math coprocessor (8 MHz). An Epson FX86e dot matrix printer was used with the system for screen dumps.

The SBE Model 11 deck unit, serial number 6, was connected to the COMPAQ computer via a GPIB (IEEE-488) interface. A Sony TC-K555 stereo cassette recorder was used to store the raw CTD data on analog tape. The schematic in Figure 5 shows the system's configuration.

Approximately 9000 m of Rochester Corporation three-conductor cable (code #I30030022MB00) was spooled onto the Markey Desh5 dc electric winch onboard the R/V *Oceanus* for use as CTD cable. Only two of the three #20 AWG 7/0.0126-in. copper conductors were usable. One conductor was shorted to the armor about 6000 m into the spool. Only one of the two "good" conductors was used during the first 31 CTD casts. The cable was reterminated, and both conductors were operated in parallel for casts 32–148.

Standard stainless steel termination cups from UW Ocean Technical Services were used during the cruise. The mechanical link used to attach the cable to the CTD unit was

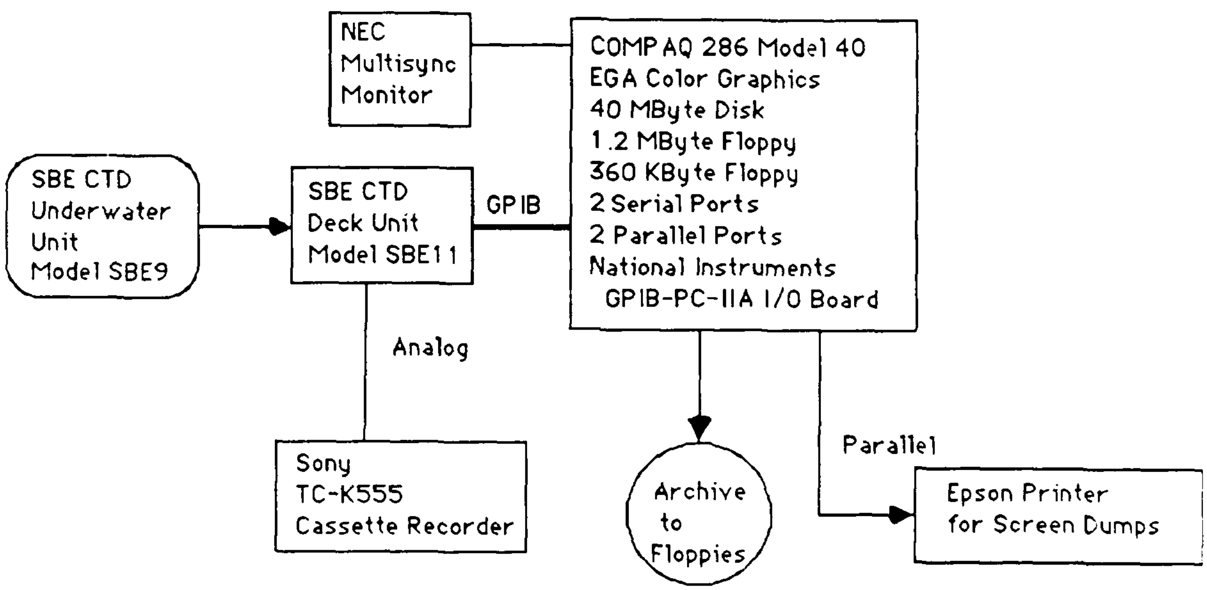

Figure 5. CTD acquisition system configuration.

a Cerrabend alloy. Individual electrical conductors were soldered, insulated from seawater, and attached to a two-pin SeaCon connector to mate with the Sea-Bird CTD bulkhead connector. Normally, the University of Washington conducts static load tests on the terminations; however, these tests were not done for this cruise.

A 1.5-liter Niskin bottle was used to collect water samples. The Niskin bottle was attached to the electromechanical wire supporting the Sea-Bird CTD unit. The bottle was attached 2 m above the sensors on the CTD. The bottle was tripped by means of a brass "messenger." Water samples were taken either at or close to the terminal depth of the CTD cast. In areas with large vertical gradients in temperature and/or conductivity at terminal depth, the sampling depth was adjusted during the messenger's fall time (200 m min^{-1}) to remain constant within several meters. Later in the cruise, the CTD was raised to a depth with a smaller gradient for better calibrations between bottle-sample salinity and sensor salinity.

In all, 148 CTD casts were made. Appendix D summarizes the station information. The first cast went down to 2500 m. All others were to either the bottom or approximately 2000 m.

2.5 XDP Drops

XDPs made by Rolf Lueck of JHU/CBI were used during leg 2 of the cruise. A special launcher was installed on the fantail for deployment. In all, 61 XDPs were deployed. Appendix E gives the drop particulars.

2.6 ADCP Data

An RD Instruments 150-kHz ADCP is installed on R/V *Oceanus* as part of the ship's scientific equipment. The ADCP system consists of a hull-mounted transducer connected by cable to a deck unit in the main laboratory. A computer is connected to the deck unit via a GBIP cable for data acquisition and storage. Prior to our cruise there were reports that the ADCP did not work. The head of the Shipboard Scientific Group at WHOI indicated there was a "beam 4 failure," and the chief scientist of the cruise preceding ours had examined the connector and noticed that some of the pins were corroded.

Two members of the APL group examined the ADCP when the ship arrived in port. They noted that there was no O-ring in the connector as there should have been. The connector leaks if no O-ring is present. The corrosion was probably caused by electric current flowing through seawater between the pins in the connector while the ADCP unit was in operation.

Two technicians were dispatched from WHOI to replace the cable and the bulkhead connector. Replacing the bulkhead connector requires removing the transducer from its mounting on the hull. In case the transducer had other damage besides just corroded pins, members of our group went into the well to put a cover plate on the hole so the transducer could be brought up to the laboratory for examination. (There was concern that the pins might have corroded all the way through the connector block, allowing seawater to enter the preamplifier electronics housing.)

As it happened, there was no easy way to cap off the hole (the cap we had was a bit too big, and we would have had to remove the recessing ring from the hull), so we gave up and put the transducer back in place. This took 3 or 4 hours at the bottom of the well, which was pressurized to about 7 psi so the water would not come in the hole in the hull.

The two technicians from WHOI arrived on 3 September and replaced the bulkhead connector. This involved unsoldering the old ribbon cable and resoldering the new one to the internal electronics. They had to take the transducer out again under 7 psi pressure.

The WHOI technicians also replaced the entire run of cable from the transducer to the deck unit in the laboratory. The cable, ordered specially from RDI Inc., contains some interesting connections at the connector to reduce noise, and it was considered impractical to try to solder another connector on the end of the existing cable and check it out in the time available.

The system worked satisfactorily at the dock when tested later on 3 September. However, it was only run for 5 or 10 minutes. It would have been better to have run it longer, because we had equipment failures soon after getting under way. If these failures had become apparent before sailing, we could have had the WHOI technicians troubleshoot the system.

After the ship got under way, the ADCP was run continuously to obtain profiles of velocity. While steaming to the first station, we noticed that the ADCP was failing. It would work for a few minutes after being turned on and then stop working. If the unit

was turned off and then on again, the computer would display a message that the RDI unit would not "wake up."

There seemed to be two problems with the ADCP. First, the so-called 5-Vdc source was closer to 4.5 Vdc, significantly less than expected. It was thought that this might be related to the wake-up problem. Replacing the power regulator board cured the low voltage state and the failure to wake up. After this fix, however, the computer would still hang up after running the ADCP for several minutes, and it was necessary to reset the system and reboot. It was not clear which part of the ADCP system was causing the problem, the computer or the deck unit. We contemplated inserting all the spare ADCP cards in the deck unit in the hope that this would cure the problem. The computer finally posted an error message indicating a problem with the directory on disk A. Disk A was not being used, so the computer itself, a NEC APCIV Power-Mate 1, was suspect.

We decided to try another computer and/or different software. A long IEEE 488 bus cable was strung from the ADCP to the COMPAQ Deskpro 286 used with the CTD system, which was running the same version of the RDI software (2.34). In this configuration, the system worked.

The backup CTD computer (an APC-3000 AT clone belonging to the University of Washington) was brought into the laboratory and used to operate the ADCP. After a few hours the screen went dark, so the ADCP was reattached to the CTD system COMPAQ Deskpro 286. Later, it was discovered that the problem was in the UW monitor and that the WHOI monitor could be used instead. This hybrid system was assembled and continued to work throughout the rest of the cruise.

It was thought that the transducer was rotated 135°, since the reference layer showed equal magnitudes for the east and north components when steaming due north. In addition, 135° was used in the software to make ADCP indicate a velocity opposite to the ship's. This orientation was confirmed on subsequent cruises.

The RDI system needs test equipment. It is virtually impossible to test it fully at the dock.

2.7 Depth Recorder

Bathymetric data were acquired continuously throughout the cruise, using a Raytheon LSR-1811 depth recorder. During leg 1 of the cruise, 15 days of bathymetry

data were acquired; 7 days of data were acquired during leg 2. Of the leg 1 data, 5 days were acquired in the vicinity of Ampere Seamount.

2.8 SAIL

The following data were acquired from the shipboard SAIL (Serial ASCII Instrumentation Loop): gyrocompass heading, ship's speed, Satellite/Omega Navigator position, wind speed (knots), relative wind direction, Northstar Loran position, sea surface temperature, and sea surface conductivity. The controller for the SAIL system was an IBM PC/XT clone. The control program for the SAIL system was Procomm, a terminal emulator program. Figure 6 shows a schematic of the SAIL system. Initially, data were acquired via the output port shown in Figure 6. However, this port broke after about half a day. Data were then acquired via the Y connection. The data acquired using these two methods have slightly different formats.

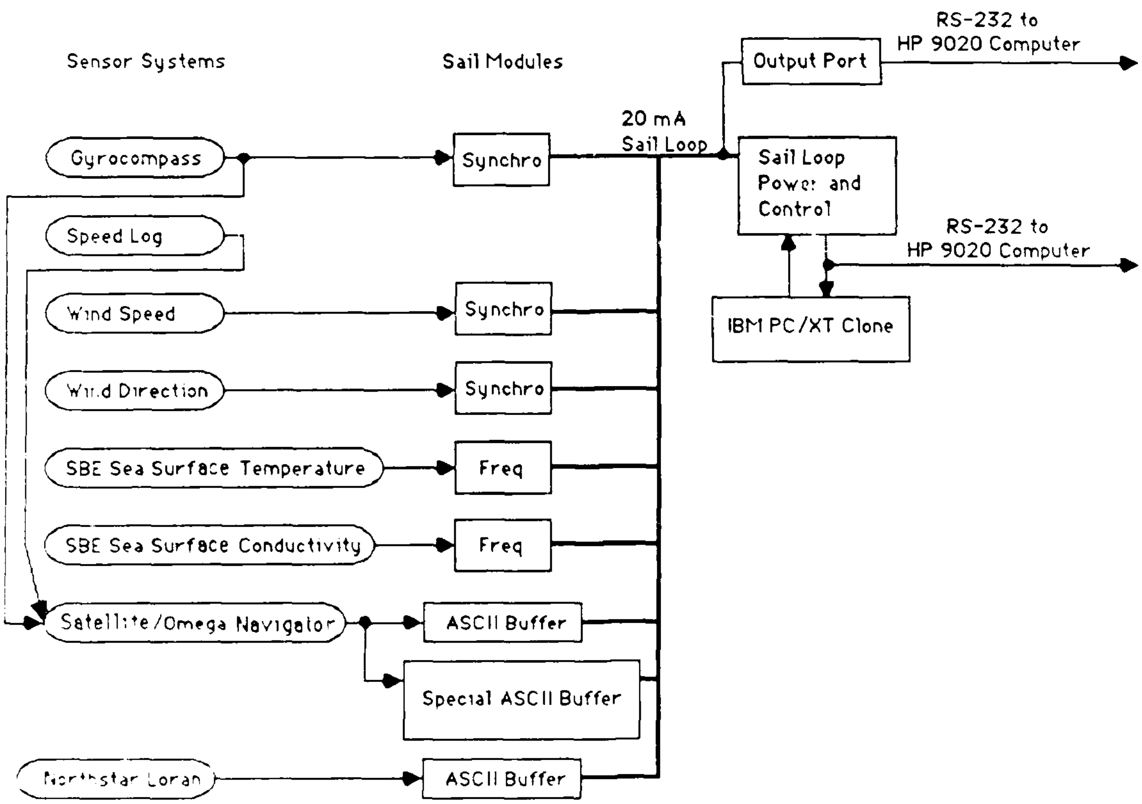

Figure 6. SAIL system configuration.

The standard ASCII buffer module captures only the first 255 bytes of the Satellite/Omega Navigator output. We wanted to get the entire 396-byte data stream. Therefore a SAIL ASCII buffer module was modified by Rod Mesecar's group at Oregon State University to discard the first 200 bytes of input data and retain the next 255 bytes. By using two modules, one standard and one modified, we were able to capture the entire 396 bytes of Satellite/Omega Navigator output.

2.9 Navigation

Accurate determination of station positions as well as the positions of the four drifters and the radar transponder was essential during this cruise. Much of the Ampere Seamount work was done with station spacings of 400 m. Other work depended on navigating accurately to repeat stations near small topographic features (seamounts) and oceanographic features (eddies). Therefore, a variety of navigation systems were used throughout the cruise and were integrated to produce the best positioning possible.

2.9.1 LORAN-C

A two-chain, range-range Loran-C system brought by the APL-UW researchers was used during the cruise. It consisted of two Megapulse Accufix-500 survey-quality receivers, each with an Efratom rubidium oscillator.

The maximum range of various European Loran-C stations was obtained from the U.S. Coast Guard, using their signal propagation model. These maximum ranges are a function of bearing and were taken to be where the signal-to-noise ratio in the model dropped to -10 dB. At Ampere Seamount only the station at Soustons, France, was within range. The stations at Estartit, Spain, and Lessay, France, were just out of range. The French stations are in a separate chain from the Mediterranean stations, so both Loran-C receivers would be required to combine data from both chains. One problem is that the timing of the two chains is not tightly controlled with respect to each other. The Mediterranean chain is within 2.5 μs of Universal Coordinated Time (750 m); the French chain's accuracy is not known by us. It was hoped that these offsets would change slowly so that they could be removed by periodic calibration with satellite fixes.

One Loran-C antenna was mounted on the catwalk between the stacks. The other was mounted on the aft port corner of the 01 deck with the coupler several feet above a

van. They were not mounted at the highest point on the ship to protect the active couplers from lightning, and they were set as far as possible from tall metal structures. The Loran-C grounding is very important. About 10 ft of No. 8 copper wire was connected between each coupler and the ship's hull. All connecting points were scraped bare, and serrated washers were used to ensure good electrical connections during the cruise. The antenna on the catwalk was installed in July before the ship left Woods Hole.

The Megapulse Accufix-500 receivers and Efratom rubidium oscillators were installed in the laboratory at the beginning of the cruise. Initially, both Loran-C receivers were set to receive the two stations of the French chain. This was to verify that the receivers and antennas were functioning correctly. Both gave the same time differences and the same signal-to-noise ratios for each station.

Later, set number two was switched to the two strongest stations of the Mediterranean chain. These stations were not as strong as the French stations, and the lock on them was lost several times until we had passed Ampere Seamount.

The Loran-C signal timing is specified at the third zero crossing. The sets are supposed to determine that crossing automatically. They usually do for good signals. The determination of the third zero crossing is hard when the signal is weak or distorted. With weak signals, the set may not be able to hear the first couple of cycles and may chose a later crossing thinking it is the third. To keep the sets from losing their lock on the signals when they were weak, the sets were forced to track a later zero crossing than they chose automatically.

The first zero crossing is not used because the signal starts with a low amplitude and builds to a maximum over 10 or 20 cycles. This slow buildup is to keep the bandwidth of the signal within ±10 kHz so the Loran-C does not use up too much of the spectrum.

Using a later crossing potentially made the sets more susceptible to sky-wave interference, which is normally delayed several cycles from the ground wave. If the sets had in fact tracked the sky wave, this would be apparent in comparisons with Omega and satellite fixes. In addition, the ship's velocity over the ground would be very erratic as the ionospheric index of refraction changed the sky wave travel times. No such trouble was noted, except that data were noisier and the signal-to-noise ratio became much poorer at night, when the sky wave is much stronger.

The French stations gave the cleanest position data while the ship was south of and near Ampere Seamount. Farther to the east, where the crossing angles from the French chain became poorer and the stations in the Mediterranean chain became stronger, the Mediterranean stations were included to advantage.

There was one several-hour-long transmission outage at a Loran-C station, and there were several times when the Mediterranean chain was too weak to receive.

2.9.2 Satellite/Omega Navigator

A Magnavox Inc. MX-1103 Satellite/Omega Navigator was part of the ship's navigation system. The MX-1103 console contains a single-channel TRANSIT satellite receiver, a three-channel Omega receiver, two microcomputers, a video display unit, and a keyboard. TRANSIT is the Navy's navigation satellite system and provides accurate position fixes (here called Transit or satellite fixes) every few hours. The MX-1103 obtains these fixes and dead reckons the ship's position from them using information on the ship's heading (from the gyrocompass) and speed (from the speed log); this information is entered electronically.

The MX-1103 attempts to compute a set and drift based on the difference between two fixes and the integrated vector computed from the forward speed and heading. This method works well when the speed and direction of the wind, current, and ship all vary slowly, but otherwise degrades.

Besides the Transit fixes and the Transit/dead-reckoned positions, the MX-1103 can give integrated Transit/Omega position fixes.

The MX-1103 on the R/V *Oceanus* bridge was operated by the officer on watch and provided Transit fixes, as well as Transit/dead-reckoned and Transit/Omega positions, once every minute to the ship's SAIL system.

2.9.3 Differential Omega

A Sercel Inc. Model M-620 differential Omega receiver was purchased specifically for this expedition. It combined standard Omega signals with differential information transmitted by certain medium-frequency (200 to 400 kHz) radio navigation beacons. The specifications indicated that position accuracy in the differential mode would depend

on the range from the differential station—0.3 n.mi. at 50 n.mi., 0.5 n.mi. at 200 n.mi., and 1.0 n.mi. at 500 n.mi.

The differential Omega antenna was mounted on the catwalk between the stacks. The mounting post, cable, and ground wire were installed in July at Woods Hole, and the antenna was quickly mounted and connected in September in Madeira. The Sercel M-620 receiver was installed in the ship's laboratory.

The differential station in Porto Santos, Madeira, was used initially and then the station in Lagos, Portugal, when it became the closer station. The operation at Ampere Seamount was nearly equidistant from these two stations, and position accuracy might have been improved if an average of the two could have been used. Unfortunately, the M-620 did not allow that. The Porto Santos station was used near Ampere Seamount.

The Sercel M-620 worked as advertised for the most part. There were several instances of losing the differential signal within 100 n.mi. of Lagos, probably because of radio propagation effects. The differential Omega position was not good near local dawn as well as near 10:00 a.m. local time. These problems have not been explored further.

Unfortunately, the ROM in the M-620 did not perform as expected and did not provide station quality indices on the RS-232 port.

During leg 1 of the cruise, data from the differential Omega receiver were averaged in near real time and passed to a Macintosh computer running NAVplus. This program graphically presented the ship's track on the Macintosh screen and was helpful in monitoring the ship's progress during the various experiments. Unfortunately, the Macintosh's power supply blew up early on leg 2, and the program could not be used.

2.9.4 Global Positioning System (GPS)

A Magnavox Inc. T-set GPS navigator was to have been part of the R/V *Oceanus* navigation system, but the GPS system was inoperable for the duration of the Gulf of Cadiz Expedition.

3. THE EXPERIMENT

3.1 Leg 1

The R/V *Oceanus* departed Funchal, Madeira, at 1200 local time on 4 September. All the instrument systems were tested and checked out adequately. The existing hand-held XBT launcher on the port quarter failed the isolation test and was replaced with a new WHOI unit. The XCP system was tested and worked well except that there was more noise on channel 16 than on the other channels. This did not appear to affect the profile quality.

A test CTD station (CTD 1) was made around 1600 GMT. The CTD was lowered at a rate of 30 m min^{-1} to 300 m and then at 60 m min^{-1} thereafter to 2500 m. The CTD station showed the classic Mediterranean water core and a σ_t that decreased monotonically with depth. Before leaving the site, two XBTs (XBT 1 and XBT 2) were deployed. Both the port and starboard XBT launchers and the MK-9s operated successfully. Figure 7 shows the location of the test drops.

3.1.1 Ampere Seamount

The R/V *Oceanus* then headed for the first operational area, Ampere Seamount. Upon arriving at the seamount on 5 September, we moored a radar transponder on the summit in water about 50 m deep at 35° 03.62'N, 12° 52.72'W at 1529 GMT. The mooring line was 100 m of plastic-jacketed steel cable. The float carrying the radar transponder was top heavy and had to be recovered to attach more weight. A weight pack prepared for the drogued drifters was at hand and was attached. The float then balanced nicely. The ship remained at the mooring site until a satellite fix was obtained.

A CTD station (CTD 2) to 1600 m was taken due east of the mooring in water deeper than 2000 m. From there the ship headed to a point 23 n.mi. northeast of the mooring. Starting at this point, XBT sections were taken around the seamount in a box pattern 60 km on a side (Figure 8). Probes were deployed every half hour (every 10 km) around the circuit.

The XBT survey was finished by 0630 GMT on 6 September. There were no apparent trends to the isotherms and thus no evidence of strong, large-scale geostrophic flows.

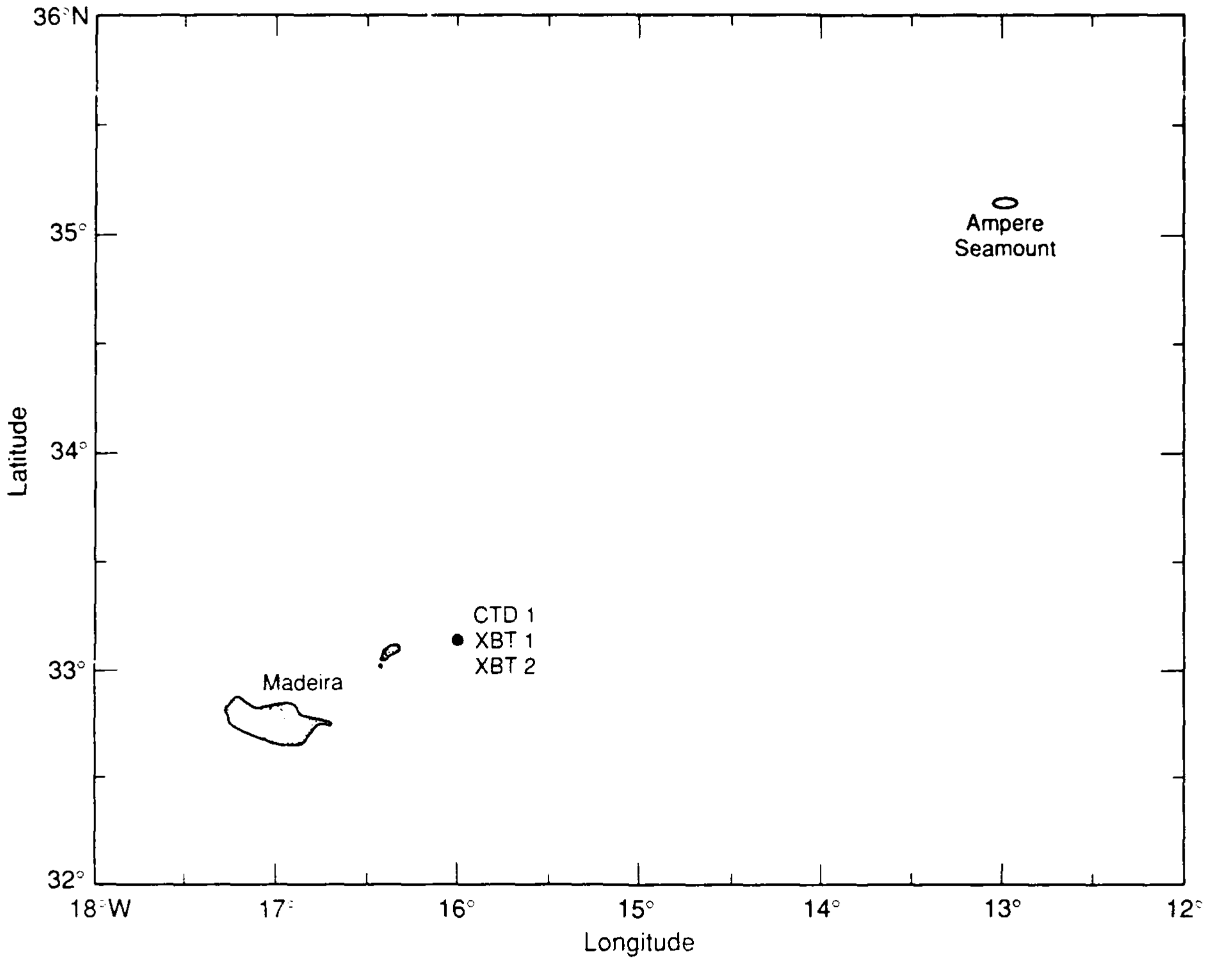

Figure 7. Test station locations.

The four initial drifter deployments were nested about 5 n.mi. around the radar transponder at sites northeast, northwest, southwest, and southeast of the mooring (Figure 8). The NE drifter, denoted #1, was deployed at 1035 GMT on 6 September. The NW drifter (#2) was delayed going in because the acoustic command receiver did not seem to respond. The unit was pinged at a 1-s rate and no response was obtained. When a 4-s rate was used and the depth recorder was momentarily on standby, the release responded every second ping (every 8 s) as expected since it has a 7.5-s blanking interval. The SW and SE drifters (3 and 4) went in easily within an hour of the previous launch. Table 2 summarizes the drifter deployments.

After drifter 4 was released and a position taken, the ship returned to the radar transponder to await a satellite fix. This fix indicated a drift of 0.4' to the east over 24 hours.

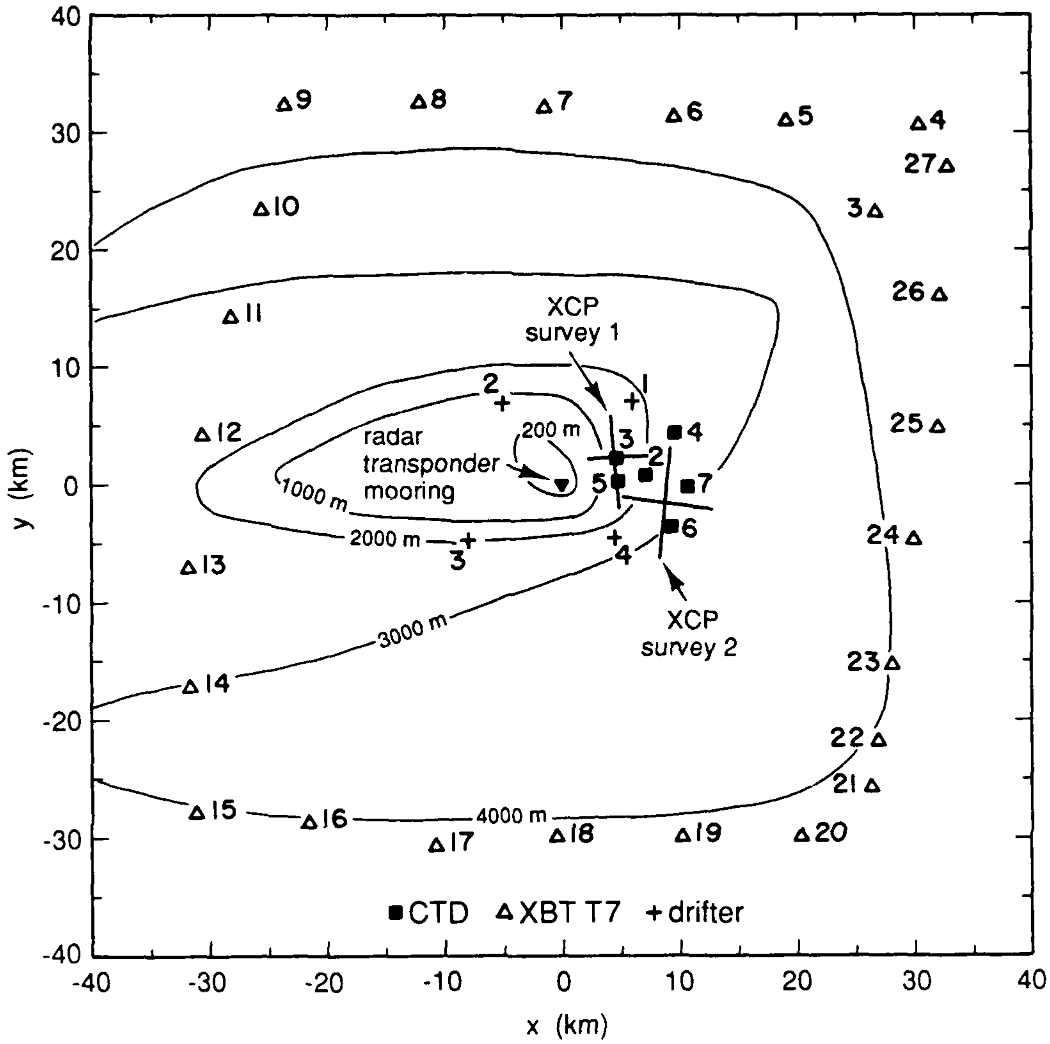

Figure 8. Locations of XBT drops, CTD stations, XCP survey patterns, and initial drifter deployments, Ampere Seamount component. Crude topography is also shown.

The average drift was about 0.3 n.mi. per day, or 0.6 cm s^{-1}. The water depth was still about 50 m. The various parts of the mooring were strung out along 110°T, about opposite the wind but in the direction of the mooring's drift.

Drifter tracking was then started. The ship would go to a drifter's last position or anticipated position and use acoustic pinging, bridge radar, and visual sightings to bring the ship alongside the drifter for a position fix. The first circuit of the drifter box was completed at 1833 GMT on 6 September. Drifter tracking continued for the next 10 hours until suspended briefly to obtain a satellite fix at the radar transponder mooring. This fix agreed well with that taken about 13 hours earlier. From the mooring, the drifter circuit was resumed at drifter 3 which by then was almost out of radar transponder range.

Table 2. Drifter deployment summary.

	Deployment			Speed (cm s^{-1})		Recovery (or last sighting)		
Drifter	Time	N. Lat.	W. Long.	$<u>$	$<v>$	Time	N. Lat.	W. Long.
1	6 Sep 1035	35°06.54'	12°49.13'	5.3	−3.3	7 Sep 1238	35°04.40'	12°44.48'
2	6 Sep 1238	35°06.21'	12°55.90'	6.9	−1.9	8 Sep 2035	35°03.68'	12°43.75'
3[a]	6 Sep 1330	35°00.41'	12°57.34'	−0.9	−13.3	7 Sep 0919	34°52.87'	12°56.76'
4	6 Sep 1443	35°00.25'	12°49.14'	0.3	−1.6	9 Sep 1149	34°57.35'	12°47.98'
5	7 Sep 1125	35°02.03'	12°49.24'	−2.0	−3.4	8 Sep 1145	34°55.91'	12°50.37'[b]
6	7 Sep 1502	35°03.46'	12°49.91'	−0.9	−5.4	8 Sep 0908	34°57.55'	12°50.12'
7	8 Sep 2142	35°04.64'	12°49.35'	1.8	−9.1	9 Sep 1844	34°59.63'	12°47.35'

[a] Lost acoustic transponder and drag line
[b] Last known position. Drifter lost and never recovered.
Drifter 5 is a redeployment of drifter 3; drifter 6 is a redeployment of 1; 7 is a redeployment of 2.
All times are GMT.

Around 0930 GMT on 7 September, drifter 3 was recovered for redeployment closer to the seamount. Unfortunately, the drifter's line had parted 2 ft below the swivel, explaining the lack of an acoustic record after deployment. Had the significance of this observation been recognized at the time, the drifter would have been examined more closely and, possibly, recovered.

Drifter 3 was redeployed (without acoustics) at 1125 GMT on 7 September 3.2 n.mi. and on a bearing of 105° from the radar transponder. Two 100-m lengths of 1/4-in. wire were used, followed by 225 ft of 3/4-in. nylon line and 85 ft of 3/8-in. chain. A new position was then determined for drifter 2.

Next, drifter 1 was retrieved for redeployment. During this operation, the thin Dacron line jumped the sheave a couple of times and could have been damaged. Finally, the blocks were adjusted properly, so the whole drifter could be winched in. The Dacron line could not be reused, but the rest of the setup could be. Drifter 1 was repositioned closer to the seamount in 1250 m of water at a range of 2.30 n.mi. and a bearing of 260° from the radar transponder. A satellite fix was again obtained at the radar mooring at 1531 GMT on 7 September. The fix indicated possible drift to the west.

The drifter tracks indicated a flow of 5–6 cm s^{-1} toward the east over the north flank of the seamount and weak flow directly to the east. The drifters were tracked during the night of 7–8 September, and a satellite fix was taken at the radar transponder at 0421 GMT on 8 September.

While drifter tracking continued during the morning of 8 September, the group prepared to conduct the first XCP survey. We decided to place an XCP cross pattern in the shear region between the eastward flow to the north and the stagnation point to the southeast; the site was 3.0 n.mi. from and at 255° with respect to the mooring, in the near wake of the seamount. Its location relative to the other stations is shown in Figure 8; individual XCP deployments are shown in Figure 9.

The west-to-east leg (XCPs 2401–2411) went well, but the radar transponder's response was lost at the end, and there was no response during the south-to-north leg (2412–2428). The transect was completed on the basis of the differential Omega data displayed on the Macintosh computer. It appeared that the ship was being set to the

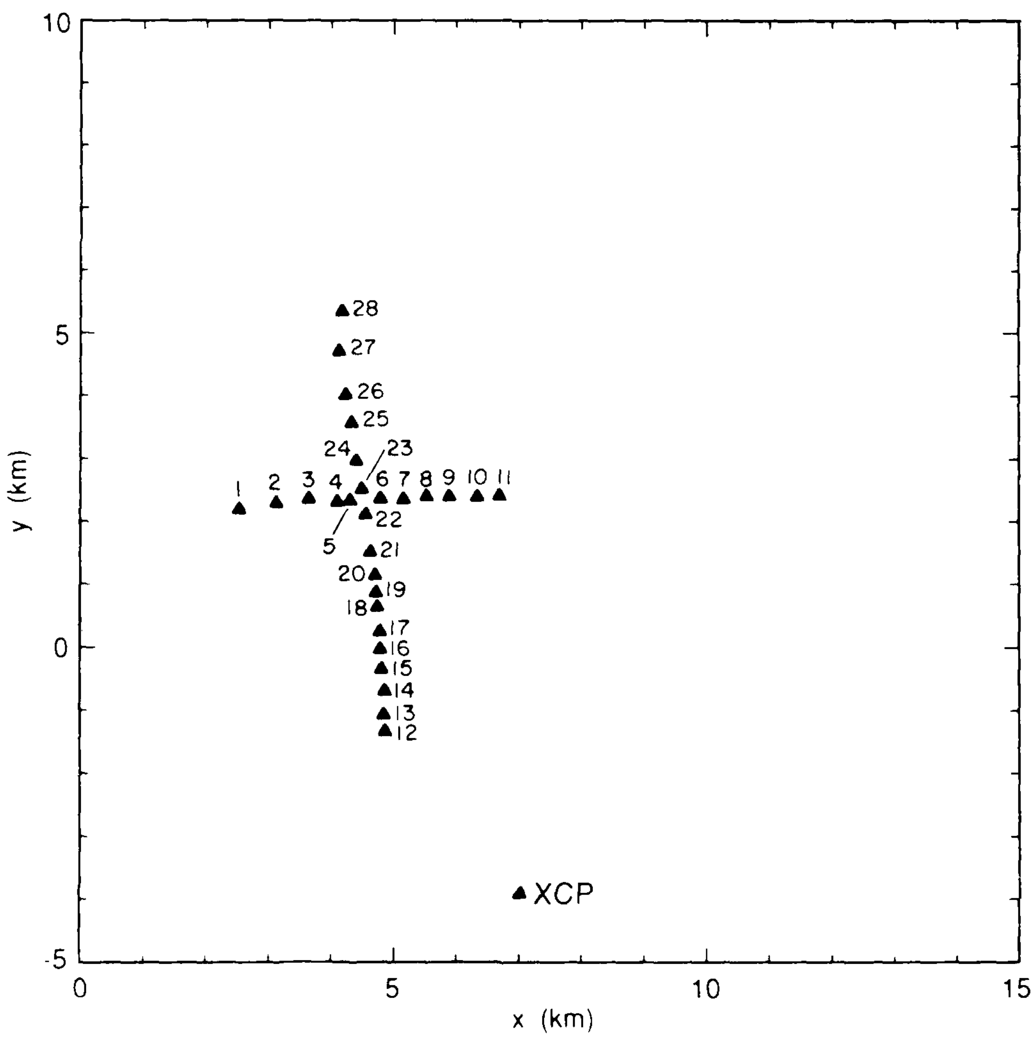

Figure 9. XCP survey 1, drop locations. Drop numbers have been shortened for plotting. Actual drop numbers are 2401 to 2428.

south by head winds and, possibly, current. More probes were launched to cover the intended section.

It was clear that we needed to get the radar transponder back in operation. The ship returned to the radar mooring at 1713 GMT on 8 September, the buoy was hauled up to the rail, and the batteries were replaced. In a fine display of seamanship, Captain Howland kept the vessel close to the anchor buoy for the few minutes needed to change the batteries.

With the radar transponder working again, the ship headed for the center of the XCP survey, and a CTD station (CTD 3) was taken to 1500 m. Drifter tracking resumed with a search for drifter 2, which was last seen moving rapidly east and out of transponder range. It was found 7.3 n.mi. from the radar transponder and recovered at 2003 GMT on 8 September. Some difficulty was encountered during recovery when the small float on the tag line started down the port side of the bow while the main float was going down the starboard side. Ultimately, things were sorted out, and the gear was brought aboard. New batteries were put in the xenon flasher, and it was redeployed at 2142 GMT nearer the seamount. Both the flasher and the acoustic transponder were working when deployed.

Drifter 4 was located at 2236 GMT. From there, we went to the last position of drifter 3 but could not find it. We spotted a light, only to discover it was the radar transponder. We proceeded to it and obtained a satellite fix at 0031 on 9 September. We then went back to drifter 4. From drifter 4, we attempted to go to drifter 1, but ended up at drifter 2 again. (Visibility was poor at the time.) From drifter 2, we did a leg to the east in search of either drifter 1 or drifter 3. Continuing our search pattern, we eventually ended up at drifter 4 but could no longer pick up the signal from the radar transponder. Without a range and bearing back to the radar mooring, we had to wait at drifter 4 for a satellite fix to get an accurate position. We continued on with tracking, passing by the radar transponder on the way to drifter 2. It was intact but not transponding. Without the radar range, we again had to wait for a satellite fix.

Drifter 1 was found at daylight while on a run from drifter 2 to drifter 4 and was recovered at 0835 GMT on 9 September. The mast was missing along with the light, but otherwise all elements were present. It was far from its expected position and may have been dragged. Drifter 4 was located later on 9 September and recovered at 1058 GMT. Then the radar transponder, its float, and the anchor float on the seamount were

recovered. Without the electronics package, drifter 3 was not considered worth searching for further.

The second XCP survey was centered 8 n.mi. east of the seamount (Figures 8 and 10). This time the section lines were twice as long. The central 2.2 n.mi. of the sections were conducted at 3 kn with drops every 5 min (the same as the first survey), but four extra drops were added to each section to provide information on larger scales; the extra drops were located 0.5 and 1.0 n.mi., respectively, from each end. This time two probes, both channel 16, failed to fall. Another channel-16 probe suppressed the AF modulation for more than 1 min into the drop, but stopped transmitting on time. One channel-14

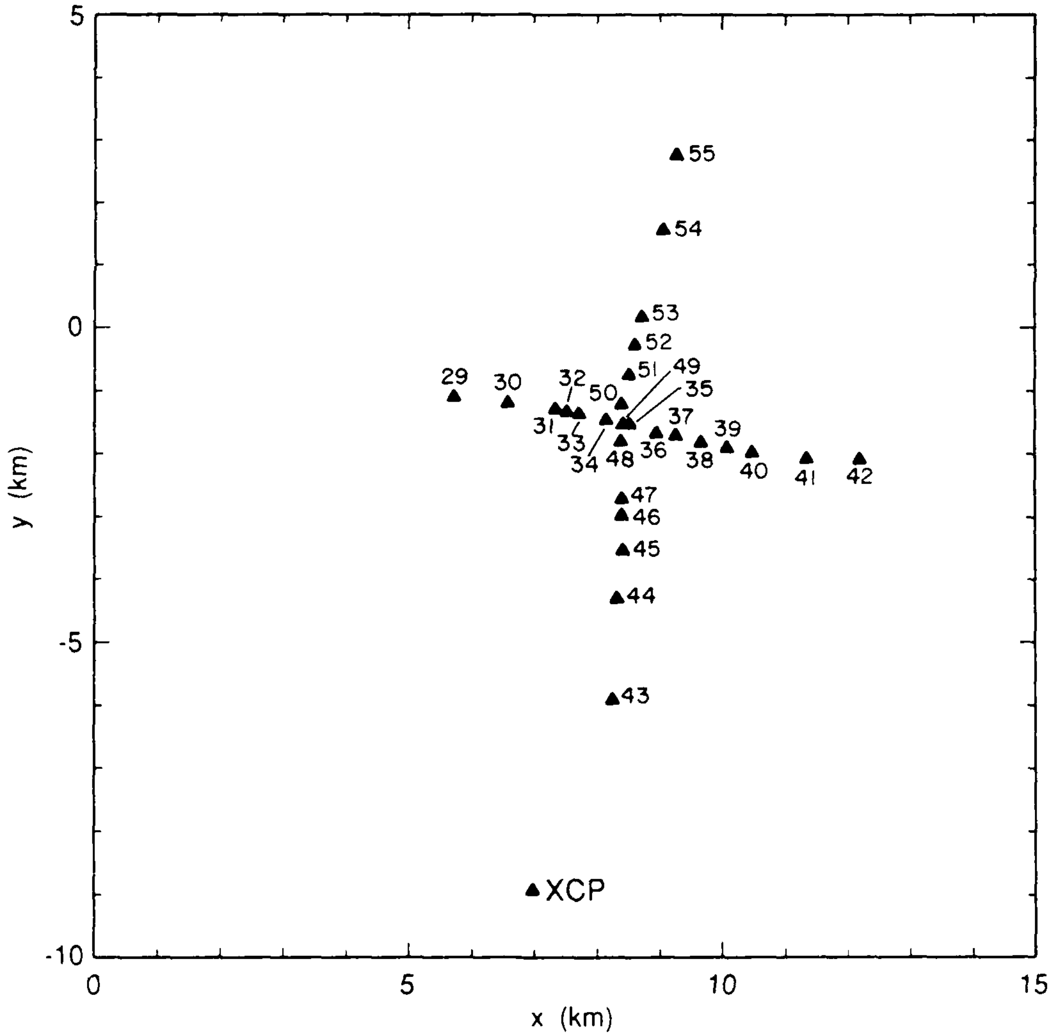

Figure 10. XCP survey 2, drop locations. Drop numbers have been shortened for plotting. Actual drop numbers are 2429 to 2455.

probe failed to shut off, but the channel could still be used for a subsequent drop. The second XCP survey was completed at 1700 GMT on 9 September. CTD station 4 was then taken at the north corner of the survey. Drifter 2 was recovered at 1840 GMT. Three more CTDs (5, 6, and 7) were taken west, south, and east of XCP survey 2. The *Oceanus* then proceeded to the next operational area off Cape St. Vincent, Portugal.

3.1.2 Meddy Component

The *Oceanus* arrived at 36°N, 8°W at 0230 GMT on 11 September to begin the Meddy phase of the expedition. Figure 11 shows the survey pattern for this experiment. Figures 12 through 15 show the locations of the individual drops and stations.

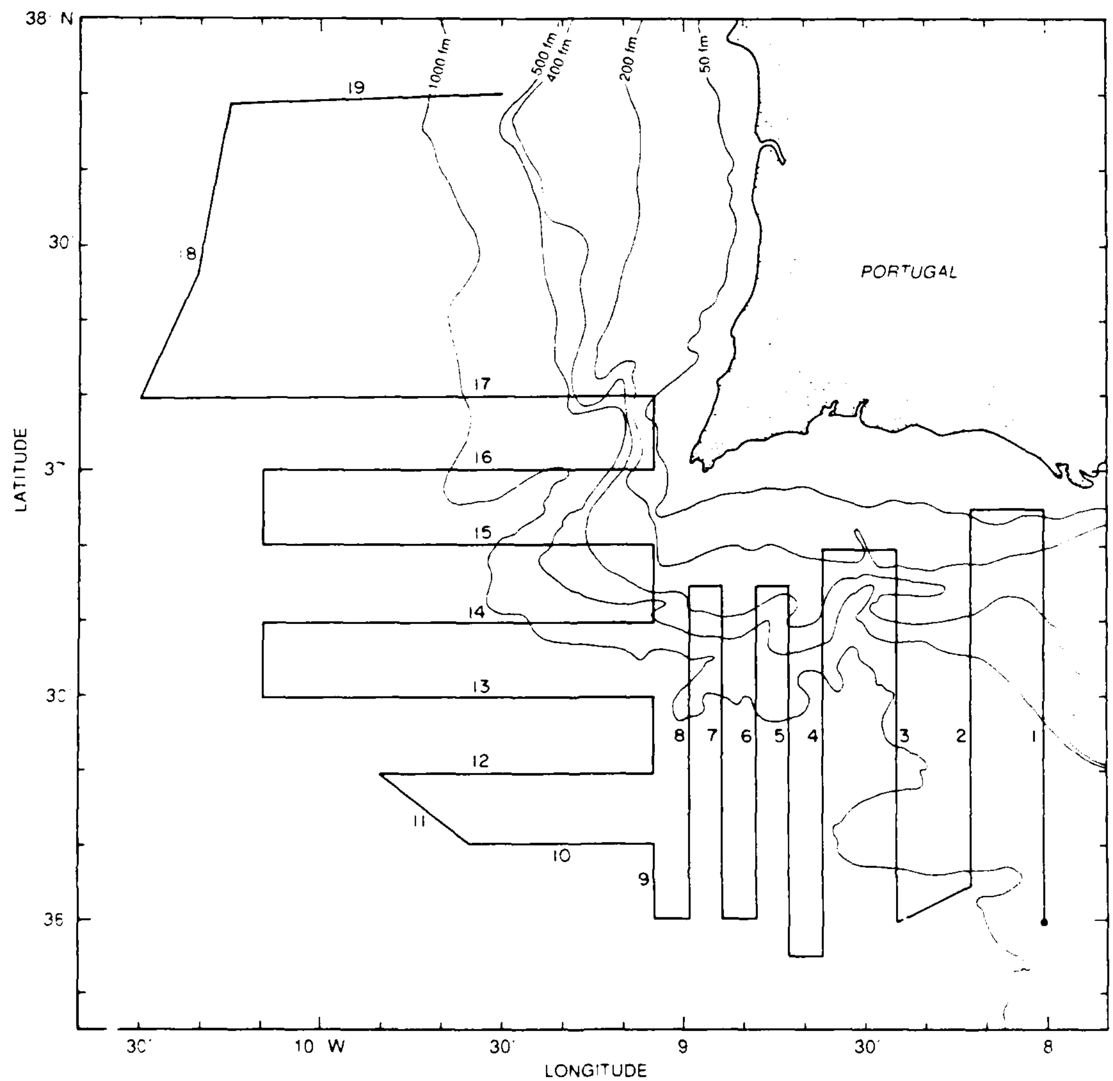

Figure 11. Survey pattern for Meddy component.

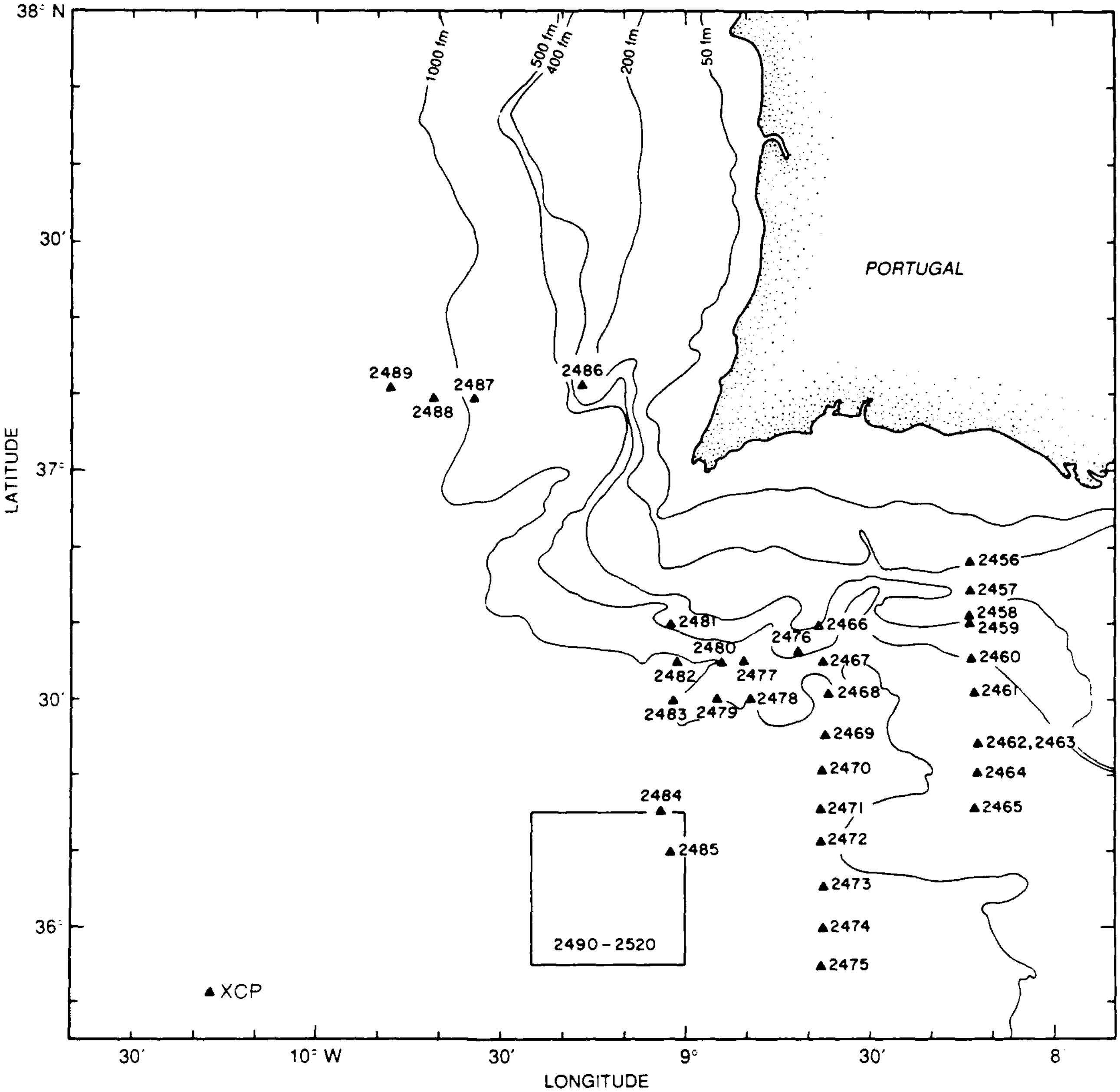

Figure 12. Locations of XCP drops during Meddy component. Drops during survey of Meddy (2490–2520, boxed area) are shown in detail in Figure 20.

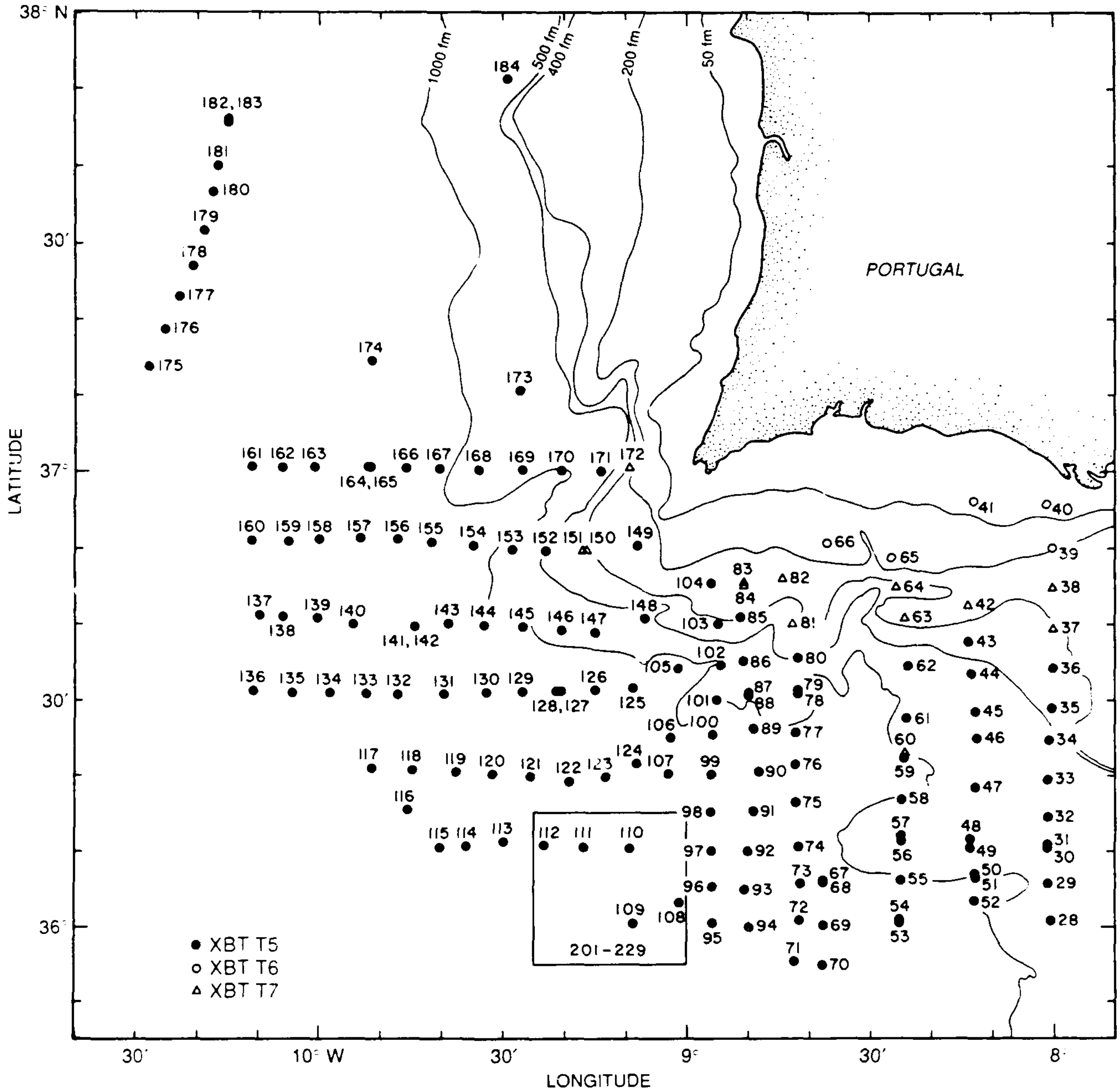

Figure 13. Locations of XBT drops during Meddy component. Drops during survey of Meddy (201–229, boxed area) are shown in detail in Figure 21.

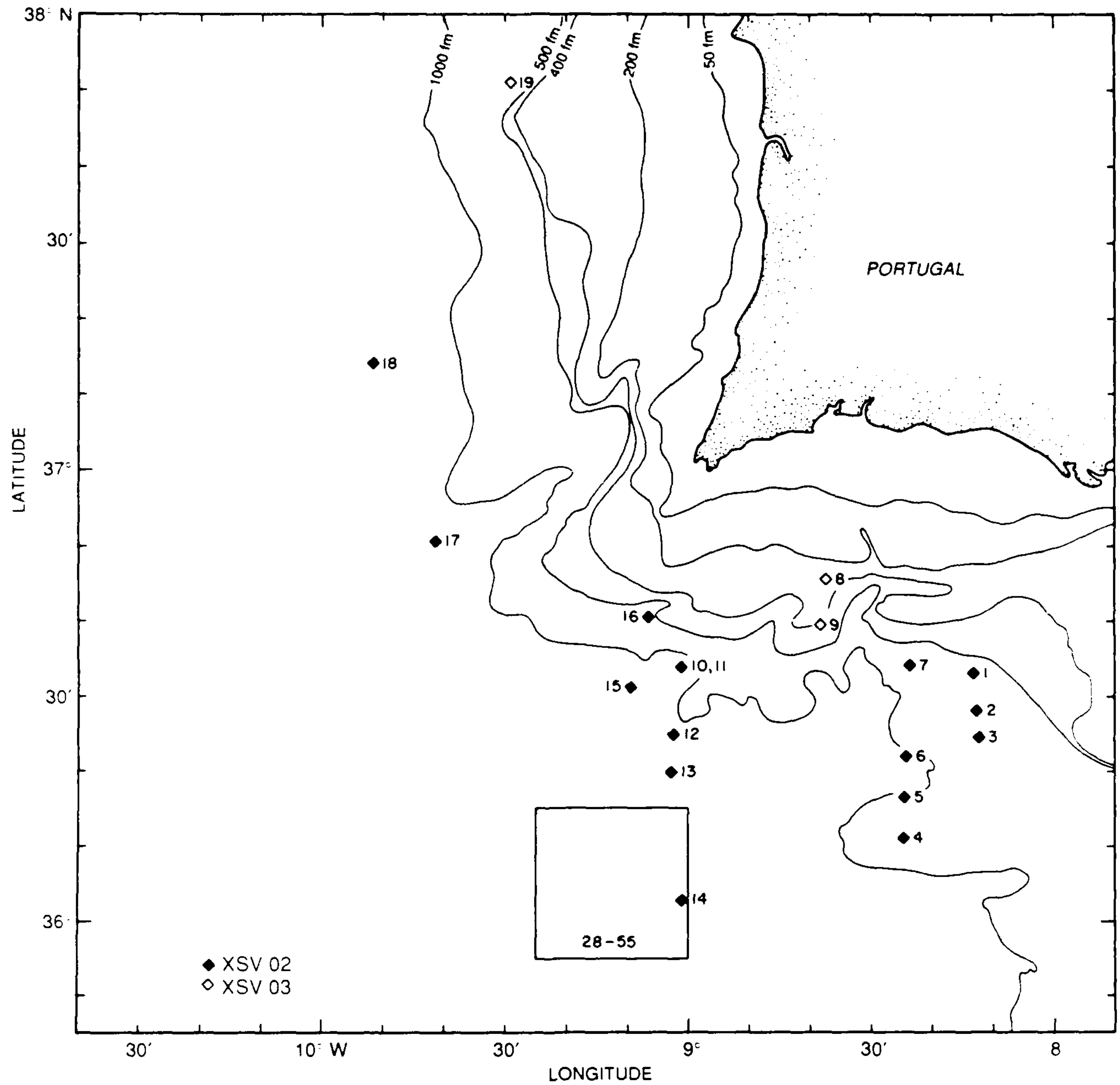

Figure 14. Locations of XSV drops during Meddy component. Drops during survey of Meddy (28–55, boxed area) are shown in detail in Figure 22.

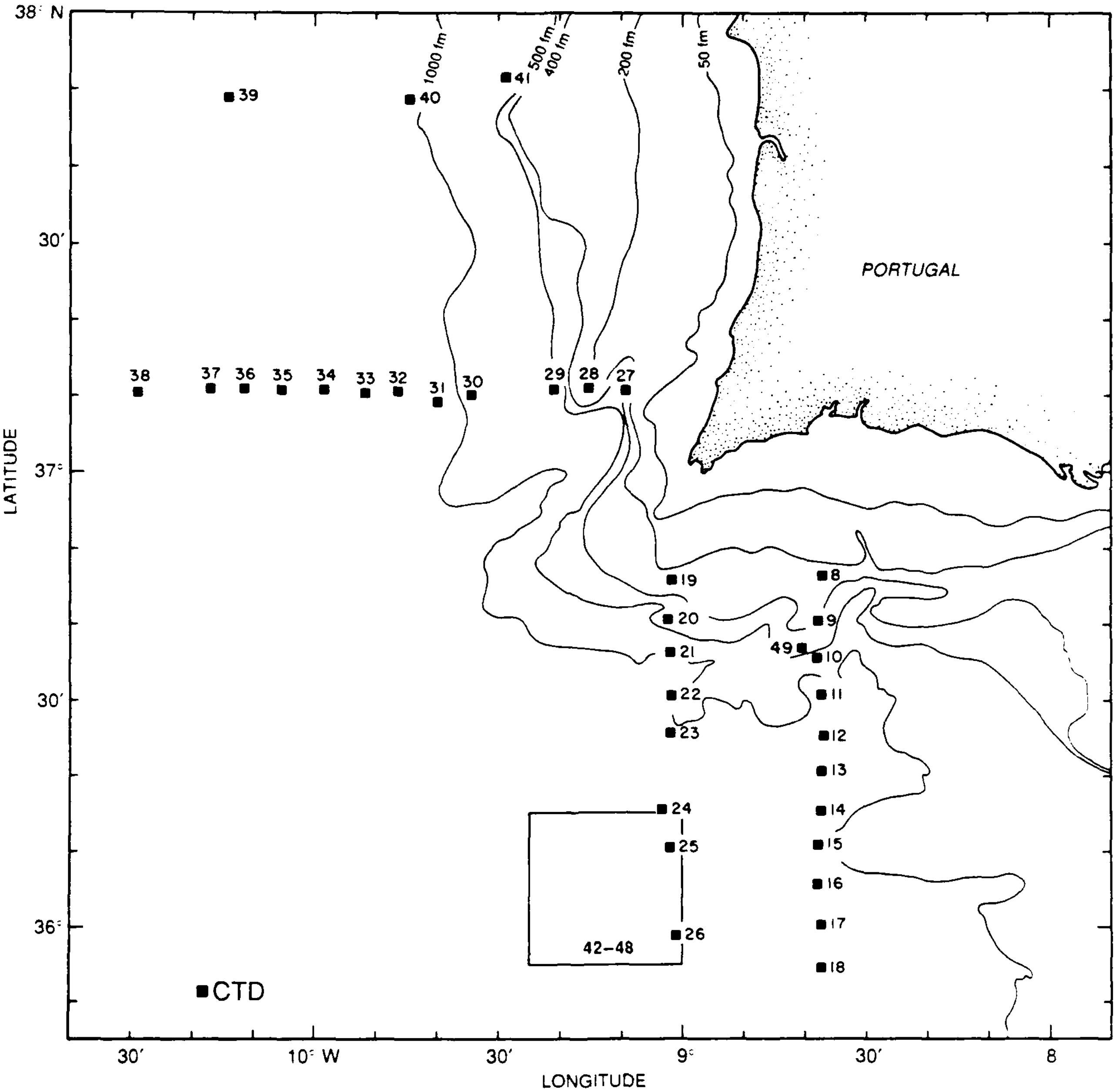

Figure 15. Locations of CTD stations during Meddy component. Stations during survey of Meddy (42–48, boxed area) are shown in detail in Figure 19.

The first line consisted of XBT drops (XBTs 28–40) and took the ship close to the Portuguese coast (Figure 13). Line 2 consisted of XCP (2456–2465), XBT (41–52), and XSV (1–3) drops. As already mentioned, there were problems with the XSVs. They would not process or display because of misalignment during manufacture. By XSV 12 however, the misalignment problem had been discovered and corrected.

On line 3 (XBTs 53–65), the type T-5 XBTs experienced high data losses. At one stage, four probes in a row failed to return good data. The equipment was examined, and a more solid ground was placed on the MK-9.

Line 4 consisted of CTD (8–18) and XCP (2466–2475) stations and took most of 12 September. The CTD data taken on line 4 revealed a strong lower core with a salinity of 36.5 psu (practical salinity units) and a weak upper core. (An upper and a lower core of Mediterranean water have been observed in this location by previous investigators, e.g., Ambar and Howe, 1979a,b.) The XCPs accompanying the section did not show any dramatic shears. Lines 5–7 proceeded without problems, but no interesting features were noted.

Most of 13 September was devoted to the CTD section along line 8 (CTDs 19–26) off Cape St. Vincent. Various blobs of water were found, but little velocity signal accompanied them. Some XCPs showed a small shear through features, but the overall impression was that the features were density-compensated and had no circulation. Whether this is a general feature of such eddies or there was little outflow at the time is not known. The CTD section was finished at 2244 GMT, and the second part of our survey was begun.

XBTs were launched through the night (lines 9–12). No particularly notable features were observed. A large swell was running from the northwest. The differential Omega system experienced some large shifts (≈5 n.mi.) around sunrise, even though the Lagos station was within 60 n.mi. Lines 13 and 14 consisted of XBTs with two XSVs at the eastern ends of the lines. Again, there was little of interest.

Lines 15 and 16 were completed, and line 17 (CTDs 27–38) was started with no unusual features found. As this CTD line progressed, a thick feature with salinity >36.5 psu was observed. There was some velocity shear across the zone and an indication of horizontal density gradients. Unfortunately, the CTD developed frequent errors.

When the computer did not get data from the GPIB for >30 s, it halted the program and erased the screen. This happened several times during a cast. The acceptable delay was increased to 100 s, which helped. The cable was reterminated using both "good" conductors, this time in parallel. (The connection to the slip rings allowed both conductors to be used.) The performance after these changes was little better. Next, the voltage threshold in the deck unit was checked. It was 2.79 Vdc; the manual indicated it should be 2 Vdc. The voltage threshold was set to 2.0 Vdc, and the pulse duration was shortened by 10–20 μs from its previous value of about 100 μs. The combination seemed to cure the problem, and the CTD could then be run at any speed without error. Unfortunately, when the test clips on the BNC cable to TP1 and GND were removed, the error light on the deck unit lit repeatedly. We decided to leave the clips attached, coil the cable into a loop, and secure it inside the unit. The CTD performed well after the fix, which occurred during CTD 33.

An additional station (CTD 37) was taken west of 10° 17'W, and more water with a salinity of 36.5 psu was found. We decided to occupy one more station at 10°29'W before transiting to the line of mooring sites off the west coast of Portugal. That station (CTD 38) showed a continuation of the rather thick (≈200 m) 36.5 psu water seen in other stations on this line. It was decided that this was not an isolated blob but a slowing spreading plume. No further stations were taken on this line.

On line 19, a CTD station was taken at each of three sites where current meters had been moored as part of the Portuguese CIRMAR (CIRculation on the Portuguese continental MARgin) experiment. The locations are summarized in Table 3. For convenience, we have denoted these moorings W, M, and E, for west, middle, and east.

Table 3. Portuguese current meter mooring locations.

Mooring	Latitude (N)	Longitude (W)	Depth (m)
W	37°46.4'	10°14.0'	3226
M	37°48.1'	9°43.6'	2000
E	37°49.9'	9°30.6'	1115

The survey data were reviewed, and we decided to study a feature seen near CTD 25 (line 8) around 1900 GMT on 13 September which had a 12°C core with a salinity of 36.5 psu (Figure 16). During the early morning of 17 September, *Oceanus* steamed to a point 5 n.mi. west of CTD 25 coming along a line from the northwest. Hourly XBTs were taken starting with the crossing of line 14, with half hourly drops after crossing line 12 (Figure 17, XBTs 185–190). Little evidence of the 12°C core was found on the way, so a box pattern (XBTs 191–200) was commenced. XSVs were also dropped during the box survey (Figure 18, XSVs 20–27). Finally, the Meddy was found about 10 n.mi. SW of CTD 25.

The first CTD station (CTD 42) was taken west of the Meddy. Stations 43 and 44 were taken at the center and eastern edge, respectively. Station 45 was taken 9 n.mi. south of the Meddy's center (Figure 19). On the run north, XCPs, XBTs, and XSVs were taken at 2-n.mi. intervals while steaming at 6 kn. About 4 n.mi. south of the Meddy's center, a most unusual profile was observed, with shear of 25 cm s^{-1} over 300 m (XCP 2494).

We continued to have difficulty getting the MK-9 to produce the correct prelaunch voltages. The XSVs need a voltage of about –4.5 Vdc before launching, and often it was necessary to turn the MK-9 off and on numerous times to get it into the correct state.

Leg 1 (XCPs 2490–2500) of a star pattern confirmed that there was a reasonable circulation (>20 cm s^{-1}) around the Meddy. Figures 20–22 show the location of the XCP, XBT, and XSV drops during the Meddy survey. Legs 2 and 3 provided additional evidence of the velocity and density structure. The run on leg 2 was somewhat marred by the need to stop and maneuver to avoid a vessel. Just about that time the differential Omega station was lost.

Two CTD stations (CTD 47 and CTD 48) were taken after completing leg 3 of the star to sample the Meddy's core further.

From there, the ship steamed to another Portuguese current-meter mooring just west of line 4. We tried for more than an hour to get an acoustic signal from the mooring on the ship's echo sounder. Neither echoes from the subsurface buoy nor the current-meter signals at 14 kHz every half hour were observed. Around 2100 GMT, a CTD station (CTD 49) was taken to the bottom, and the ship departed for Cadiz.

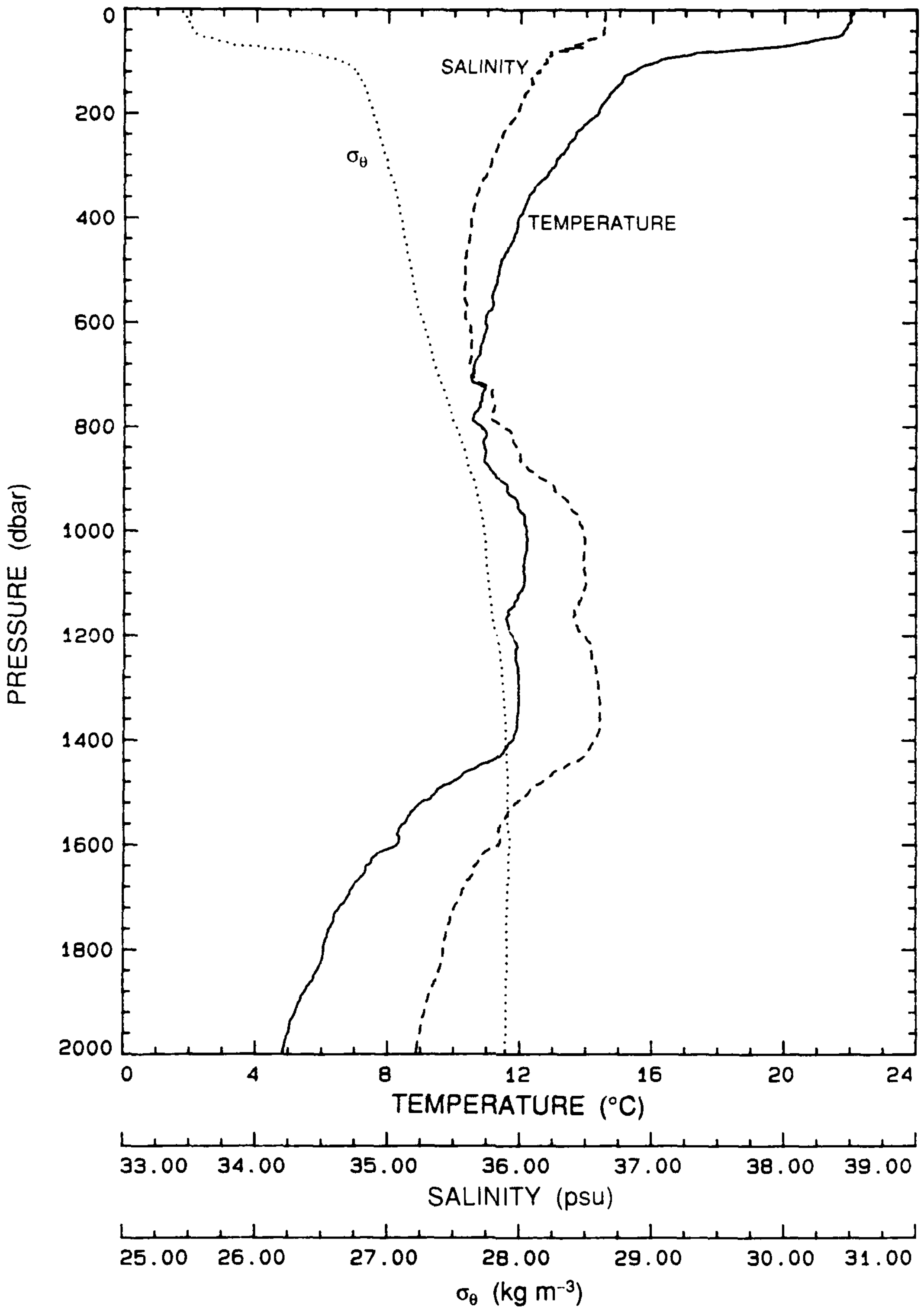

Figure 16. Temperature, salinity, and σ_θ data from CTD 25.

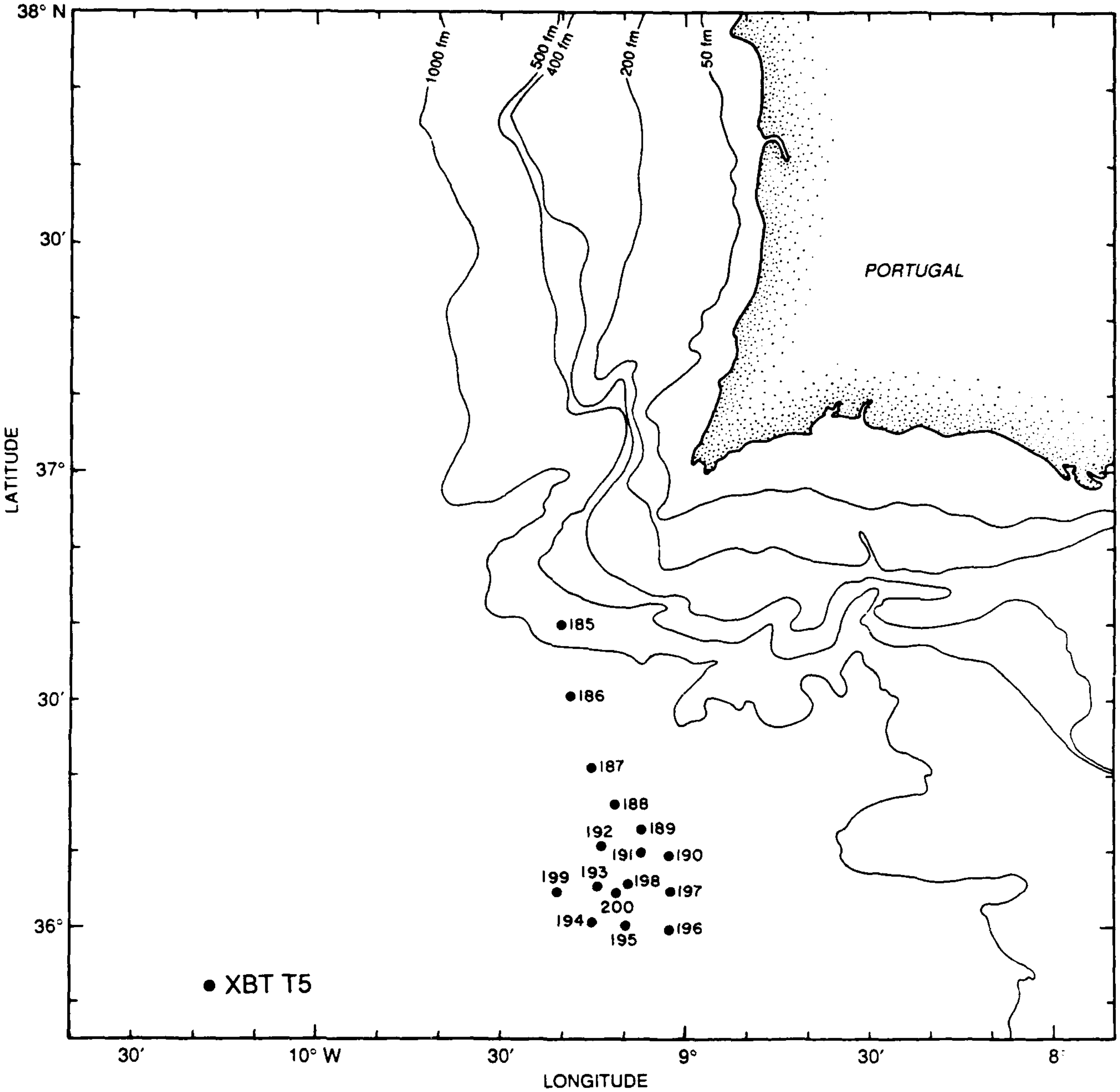

Figure 17. Locations of XBT drops enroute to Meddy and box pattern.

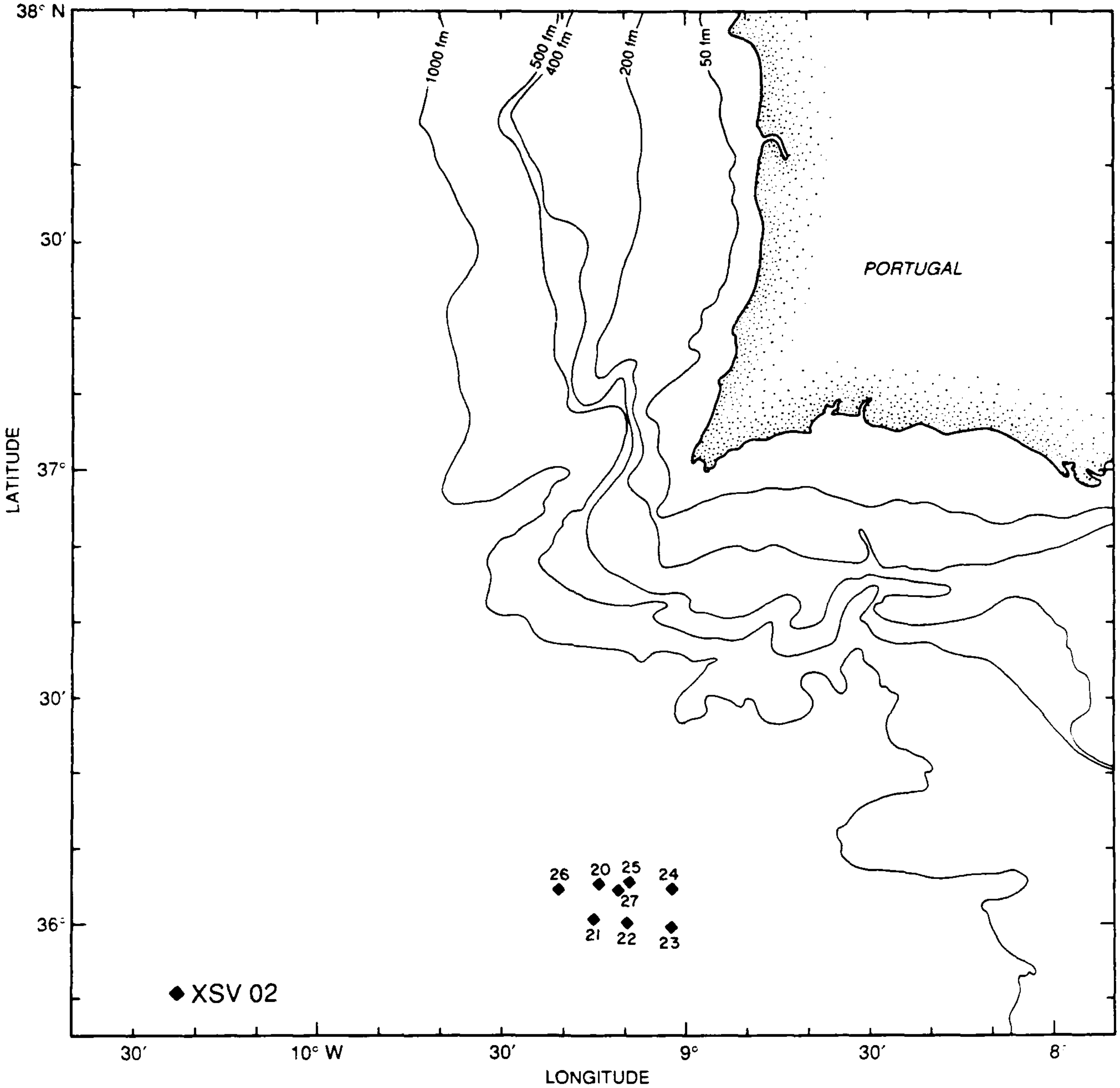

Figure 18. Locations of XSV drops during box pattern.

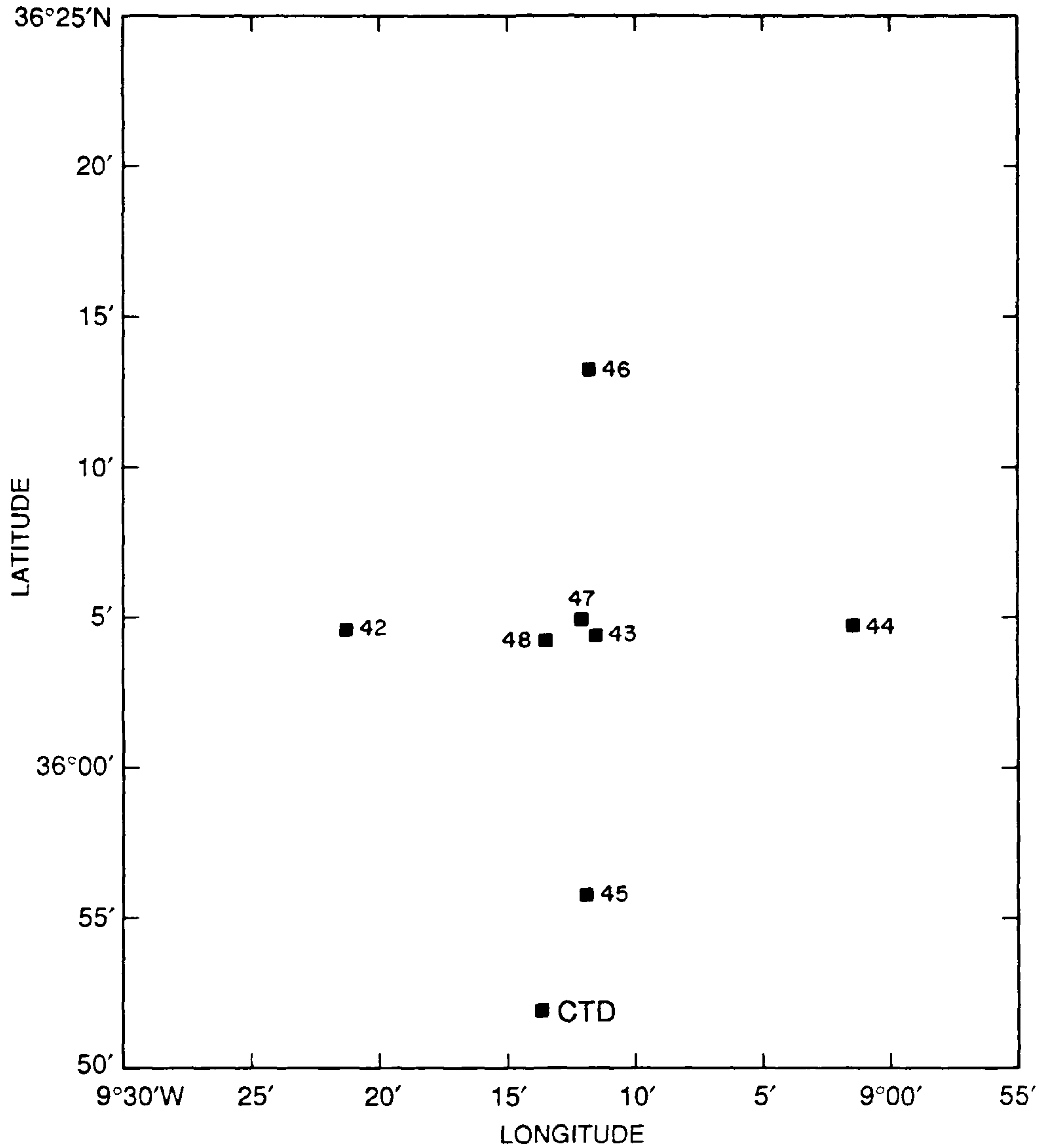

Figure 19. Locations of CTD stations around Meddy.

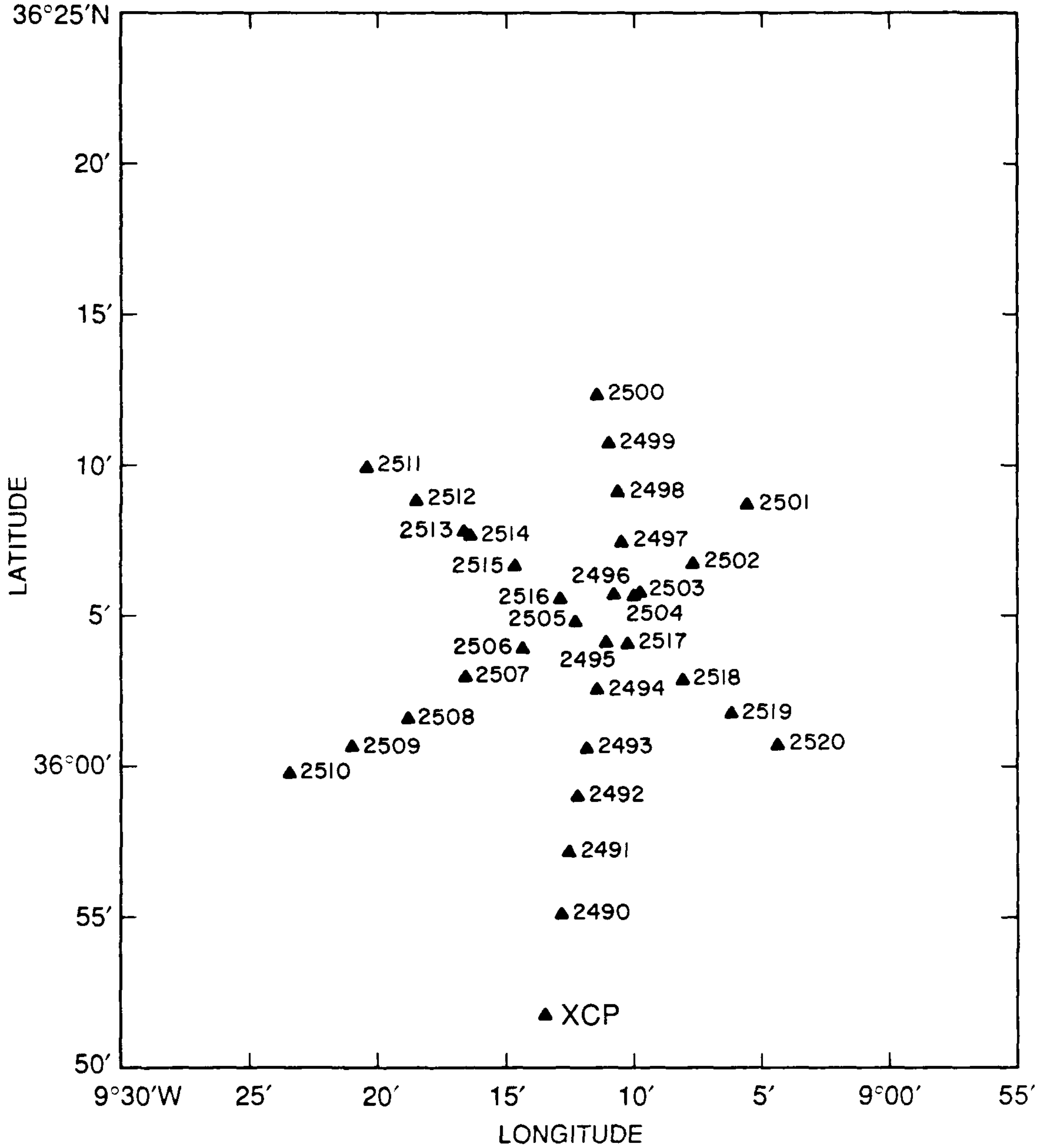

Figure 20. XCP drop locations in Meddy.

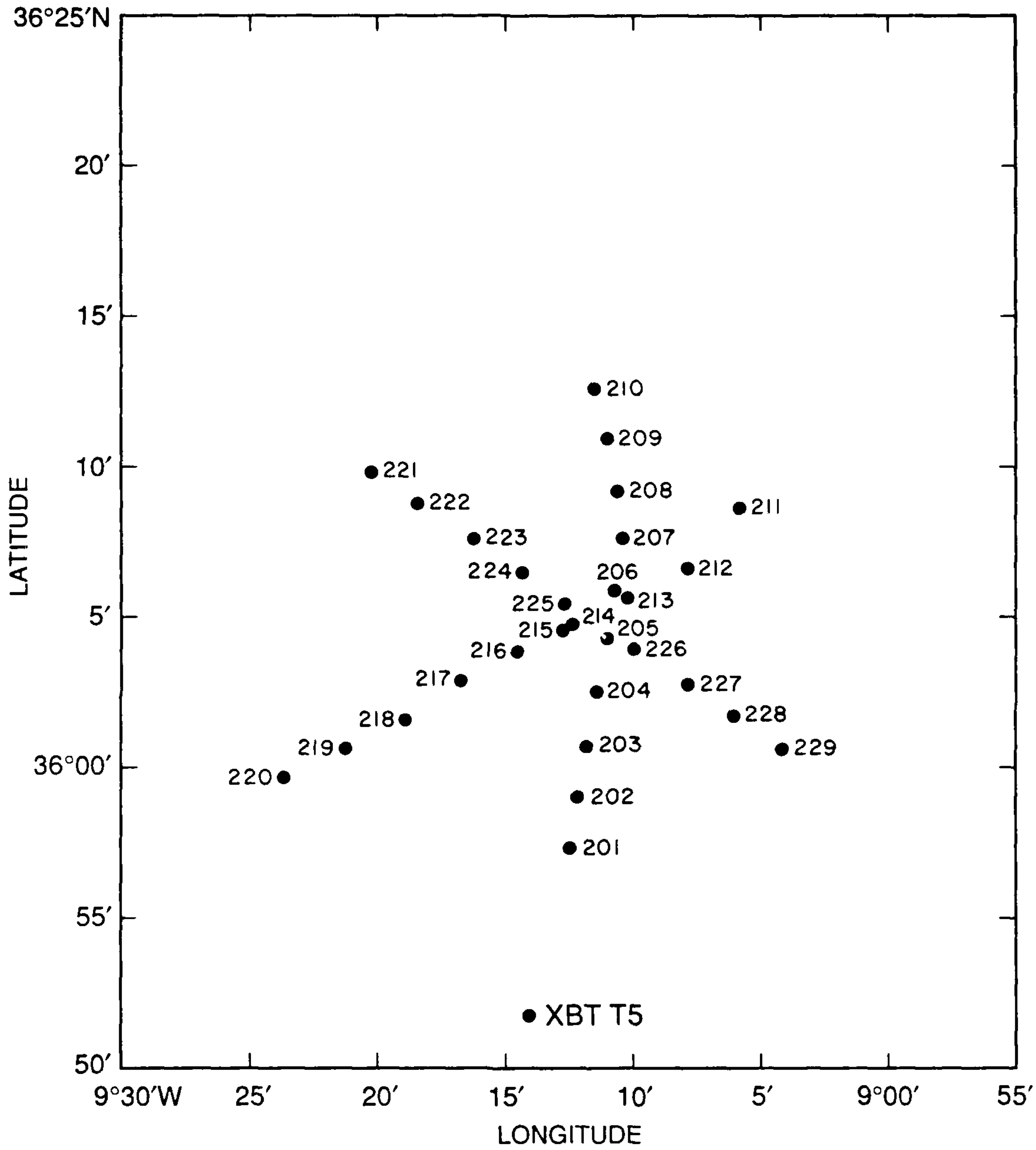

Figure 21. XBT drop locations in Meddy.

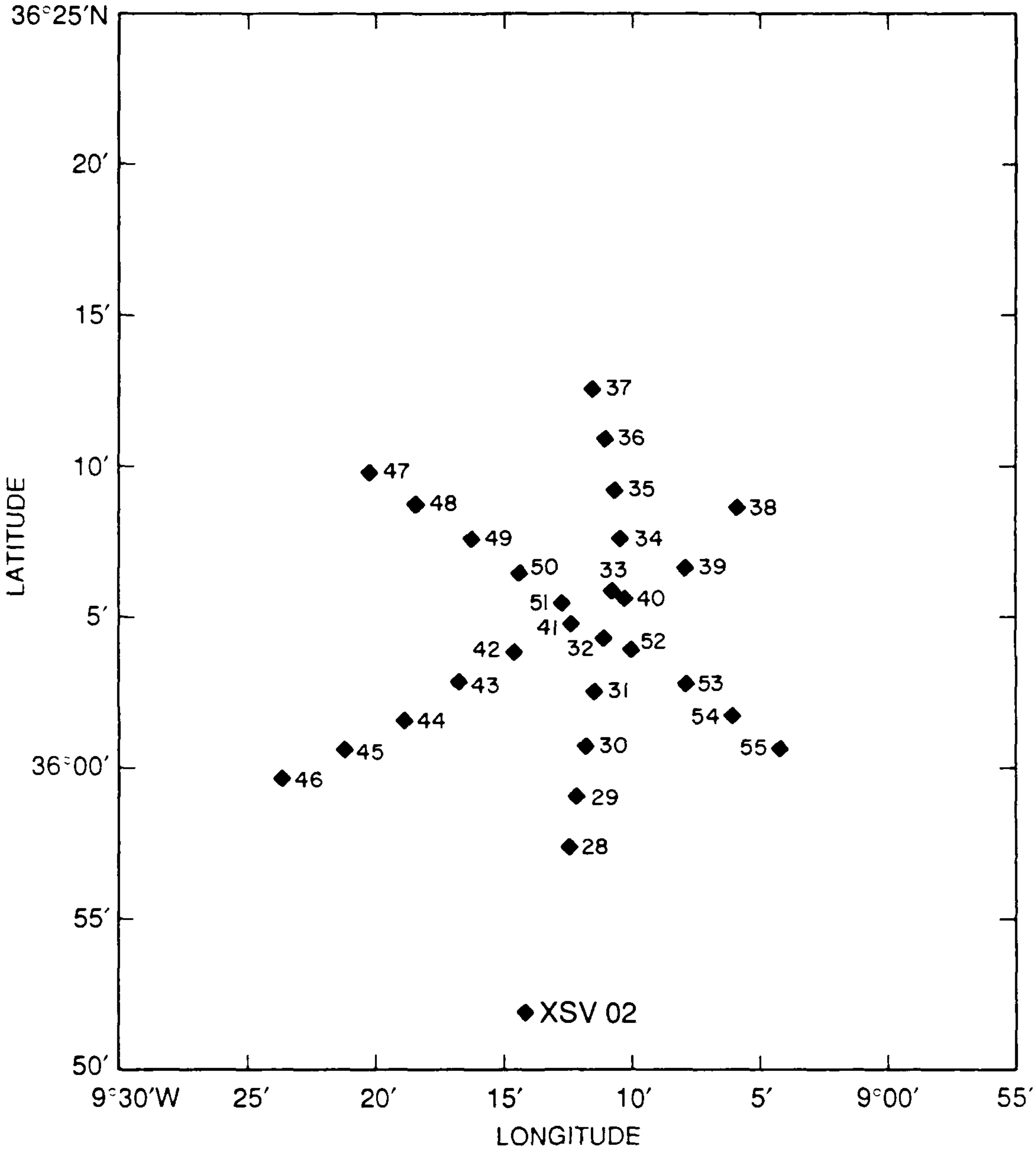

Figure 22. XSV drop locations in Meddy.

3.2 Leg 2: The Mediterranean Outflow

After a brief stop to change personnel and load the XDP equipment, the *Oceanus* departed Cadiz, Spain, at 0900 GMT on 21 September. Before commencing the sections that had been planned across the axis of the outflow plume, we selected individual sites at which to make measurements (see Table 4 and Figures 23–25). After a brief transit to site 1, we took a CTD station (CTD 50) at 1310 GMT (Figure 23). We then took a CTD station (51), an XCP drop (2523), and an XDP drop (801) at site 2 to the east-northeast. At site 3, a bit farther northeast, we took another CTD (52), XCP (2525), and XDP (1030) station. The water mass (Figure 26) and velocity structure at each of these sites appeared very similar. The source for the outflow appeared to be adequately described by site 1 and maybe sites farther to the west. Therefore, we decided to leave site 3 and concentrate on those sites. The *Oceanus* returned to site 1 for CTD station 53, XCP drop 2527, and XDP drop 1040.

Table 4. Location of sites on leg 2, outflow component.

Site No.	N. Latitude	W. Longitude
1	35°49'	6°13'
2	35°51'	6°01'
3	35°53'	5°53'
4	35°46'	6°20'
5	35°45'	6°28'
6	35°49'	6°37'
7	35°54'	6°31'
8	35°56'	6°26'
9	35°44'	6°37'

We then steamed to site 4 at 35°46'N, 6°20'W to look for evidence of appreciable mixing. We wanted to occupy a site about 500 m deep, some 100 m deeper than at site 1. However, the depth was about the same as at site 1, so we decided to steam north awhile to look for deeper water. After steaming north and then south, we learned that our original choice was about the deepest along this meridian. An XCP drop (2528) showed a large and unidirectional shear (0.02 s^{-1}) right into the bottom. A CTD cast (CTD 54) showed a lowering of the maximum salinity.

Because a good deal of time was lost conducting the bathymetry survey at site 4, we decided to head south and then north looking for the deepest part of the channel. The

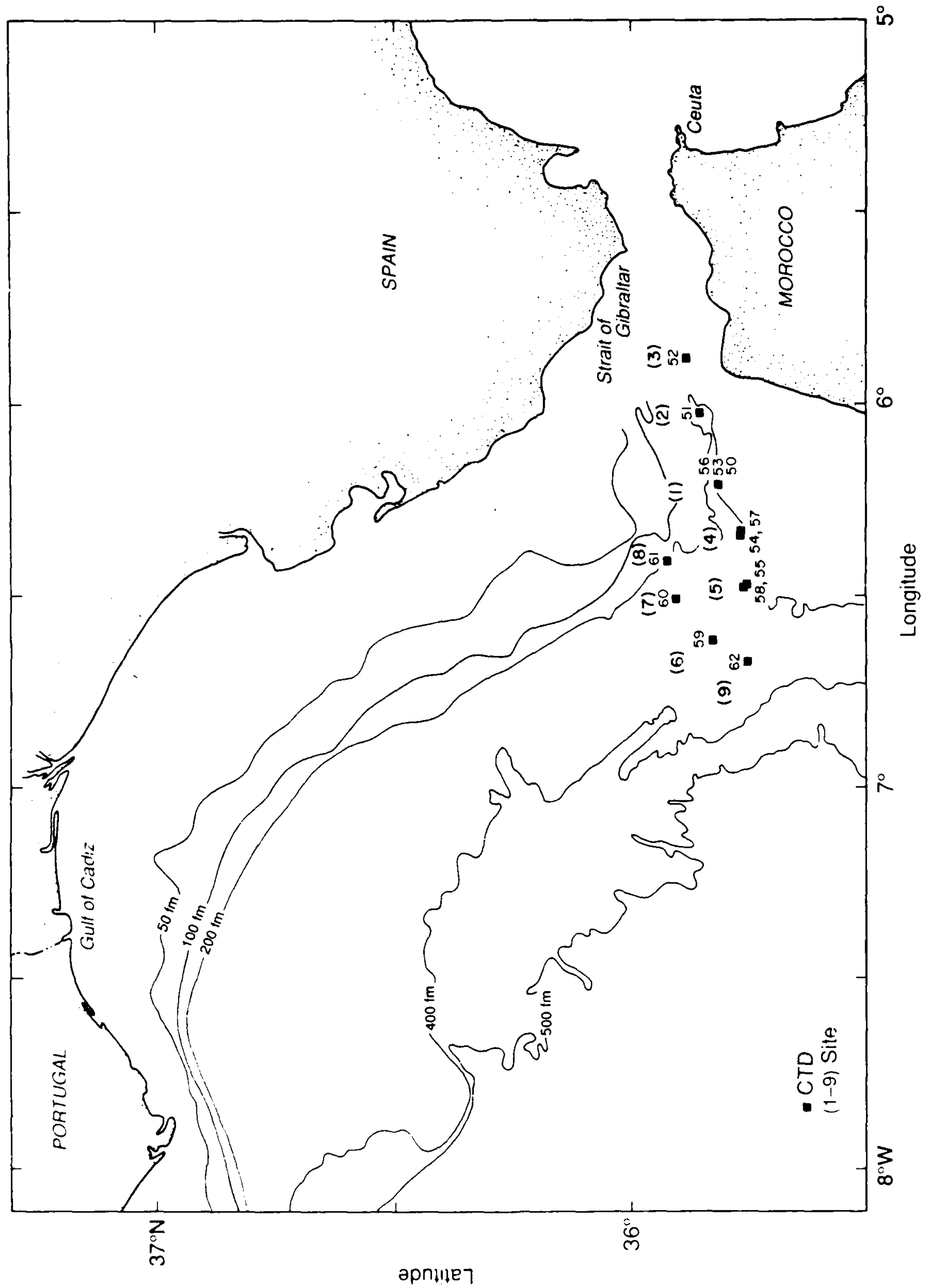

Figure 23. Locations of CTD stations. Site numbers are in parentheses.

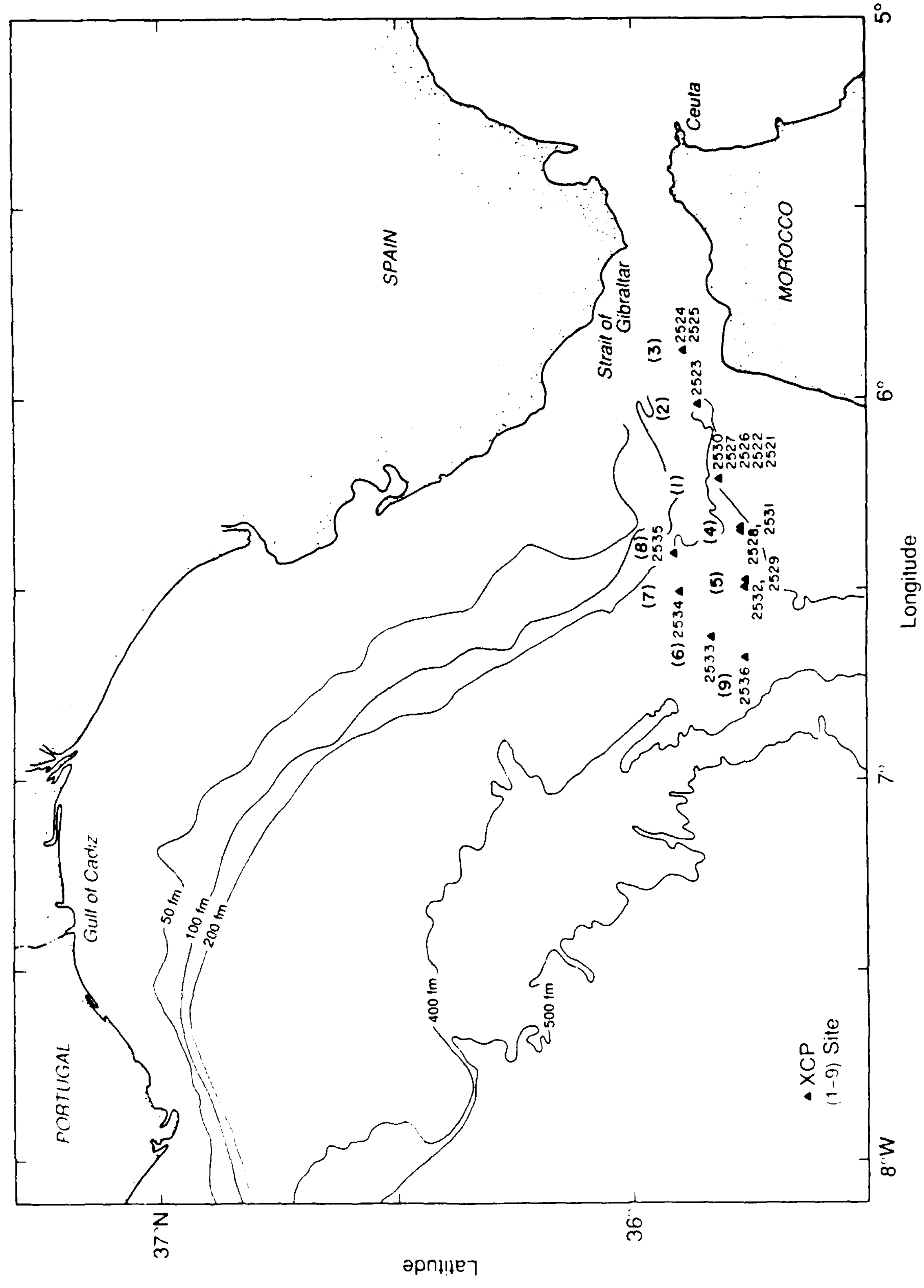

Figure 24. Locations of XCP drops. Site numbers are in parentheses.

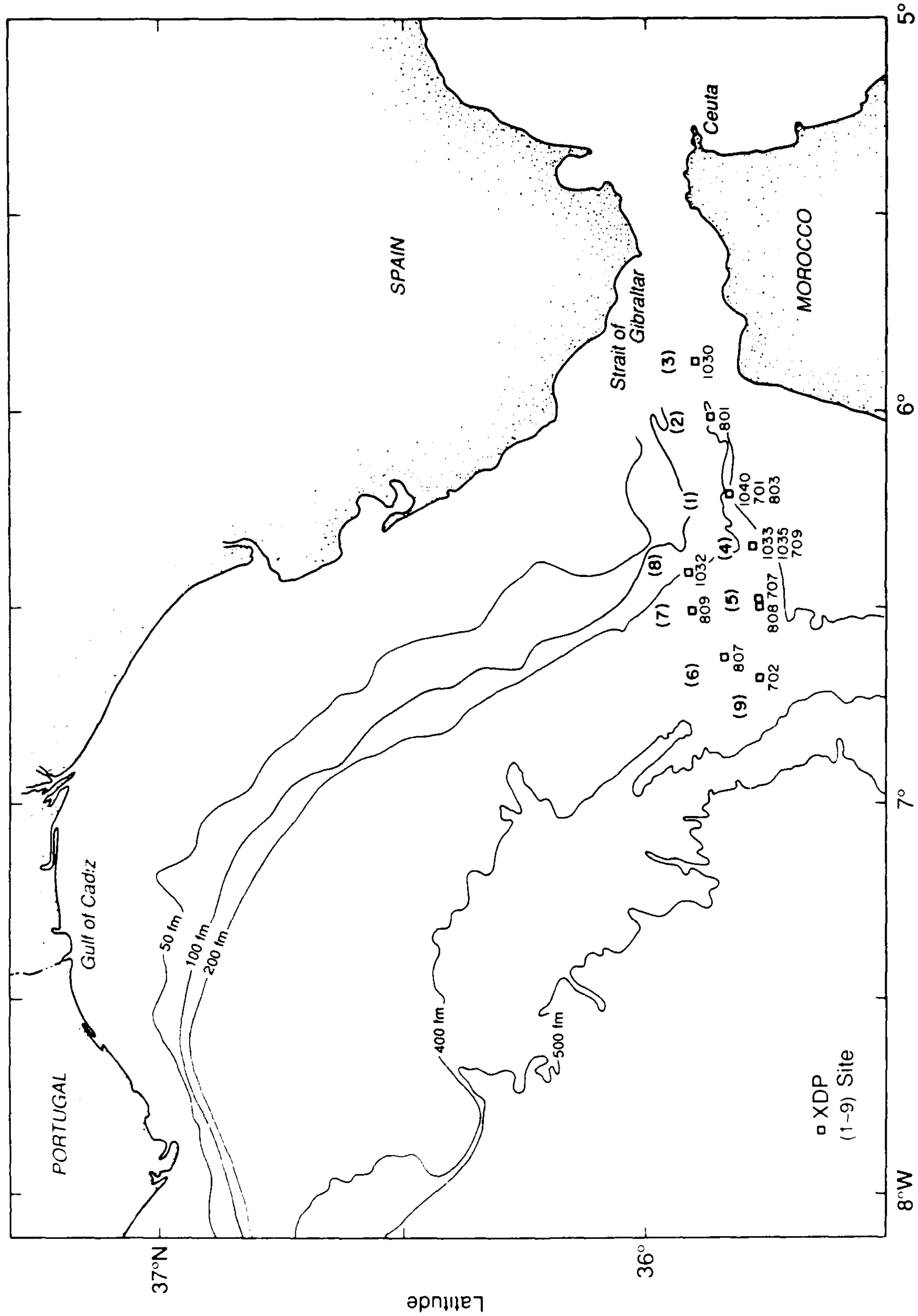

Figure 25. Locations of XDP drops. Site numbers are in parentheses.

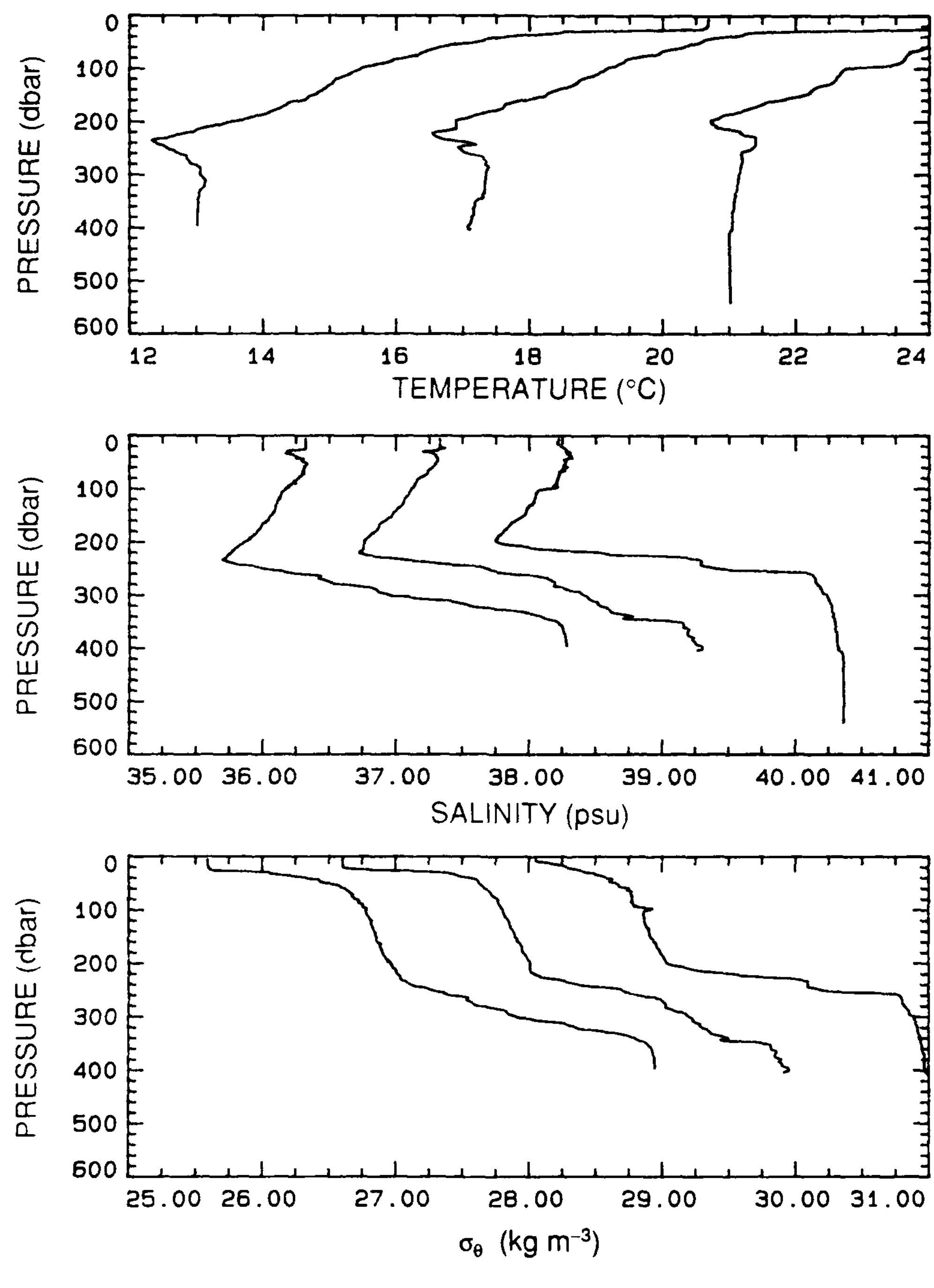

Figure 26. Temperature (top panel), salinity (middle), and σ_θ (bottom) for CTD stations 50–52. The leftmost profile is plotted to scale. The other profiles are shifted successively 2.0° for temperature, 1 psu for salinity, and 1 kg m^{-3} for σ_θ.

channel along 6°29'W was rather flat, but there was a deep groove west-southwest of site 4 where we located site 5. The data showed a strong southwest bottom jet (XCP 2529), but the flow reversed about 40 m above the bottom, as if bottom drag were beginning to decelerate the flow.

Site 7 was at 35°54.24'N, 6°31.29'W, along a line about 060° from site 6. Here there was only a weak jet ($v < 50$ cm s^{-1}, XCP 2534), but the salinity was about 37.0 psu (CTD 60). The results at sites 6 and 7 conform to those of Serrano (1962). The low velocities were puzzling, but the salinity and density anomalies disappeared as expected. A station to the northeast seemed appropriate to complete this preliminary study. This station (site 8) showed no Mediterranean water and little velocity (CTD 61 and XCP 2535).

Because stations 6–8 did not indicate large flow, we decided to make a cast at a location more down slope from site 5. This location (site 9) contained considerable Mediterranean water (CTD 62 and XCP 2536).

On the basis of the information on hand, we decided to begin with section A through site 1. Section B went through site 5, and section C farther west through site 9. Figure 27 shows the locations of the sections, and Figures 28–30 show the CTD stations and XCP and XDP drops.

Section C was completed the morning of 23 September and section D by late evening. After station D12, the ship returned to station C4 to obtain a dissipation profile (XDPs 1049 and 804) along with CTD (CTD 91) and velocity (XCP 2556) profiles. Rolf Lueck had had poor success during section C and wanted to obtain a profile at station C4.

Most of section E was completed on one watch. Before continuing the sections, we decided to conduct a preliminary bathymetric survey to make sure we were not being fooled by any topographic features. We steamed along the new section, denoted section F, until the 300 m contour, then turned around and hit all the deep channels. In hindsight, it was not clear that the extra steaming was worthwhile. The work went on until mid-morning of 25 September.

The next section, G, was along a line at 033°T and had 12 stations. It was argued that we should complete the CTD lines and then go back to the Strait of Gibraltar for a run along the principal channel. One reason was that the moon would be full in a day or so, and it was thought that the spring tides might produce different flows and mixing. However, the moon appeared almost full during the early morning of 25 September.

Section G was completed around 2100 GMT, and the ship steamed to section H, a line down the 8th meridian. The station spacing on sections G and H was 5 n.mi. Section H was extended to the middle of the Gulf of Cadiz, where an additional station, H11, was taken at 35°53'N, 8°00'W in mid-afternoon of 26 September.

Station H11 seemed to be far enough to provide a mid-gulf profile, and no more stations were taken on this line. Instead, a short line of stations, denoted as section FE, was conducted between the ends of sections F and E.

During the early morning of 27 September, the ship steamed to station I1 south of Gibraltar. During the afternoon, the stations on line I were occupied, ending with station I10 at 1974 GMT. Thereafter, just XCPs and XDPs were launched until the supply was exhausted around 0200 on 28 September. The ship then headed into port at Cadiz.

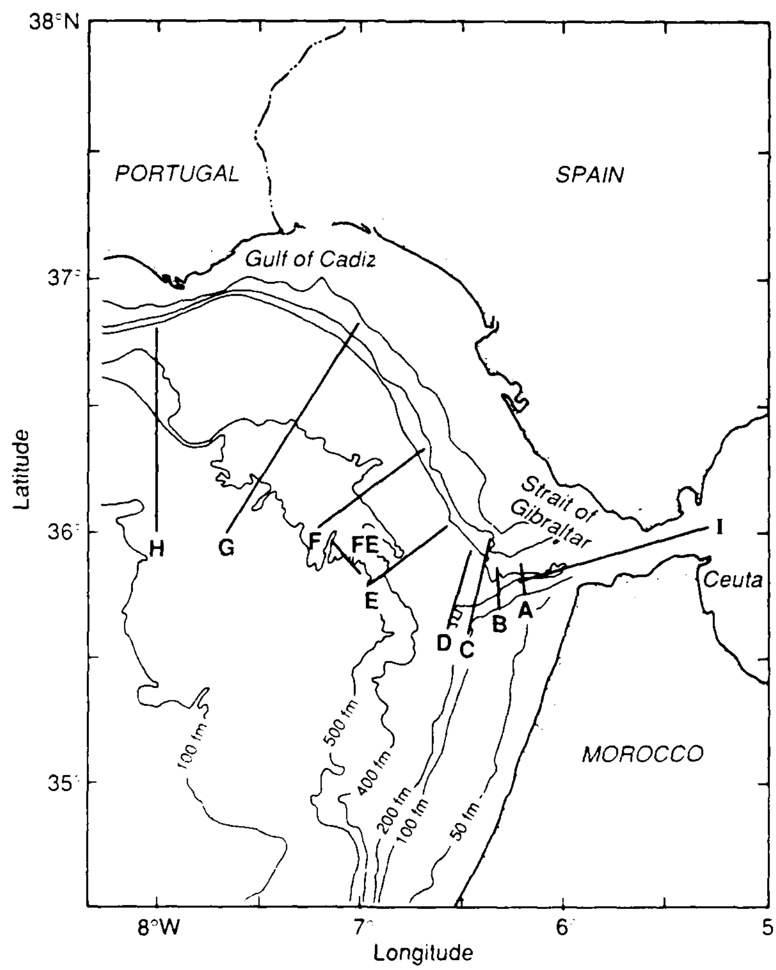

Figure 27. Section plan.

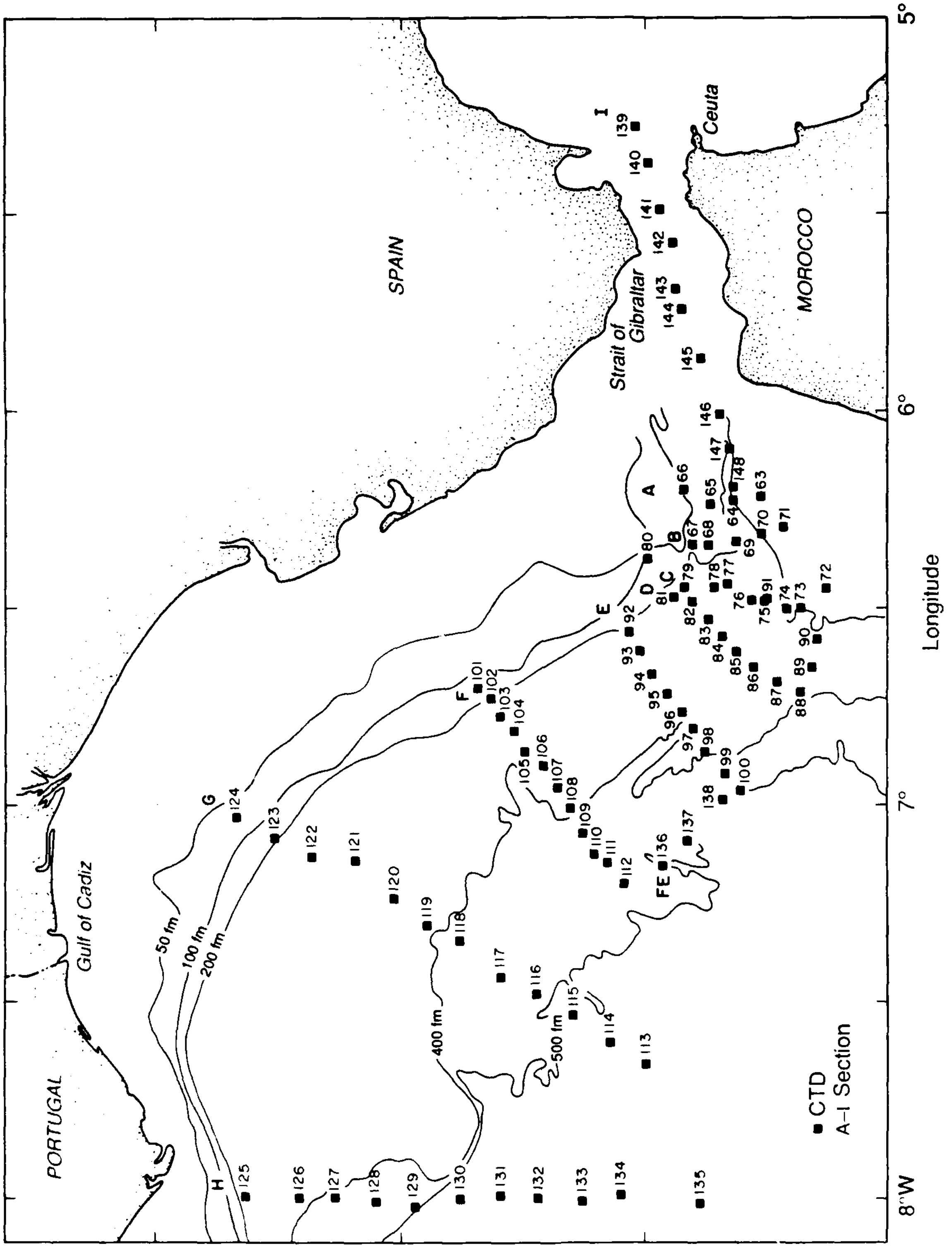

Figure 28. CTD stations, sections A–I.

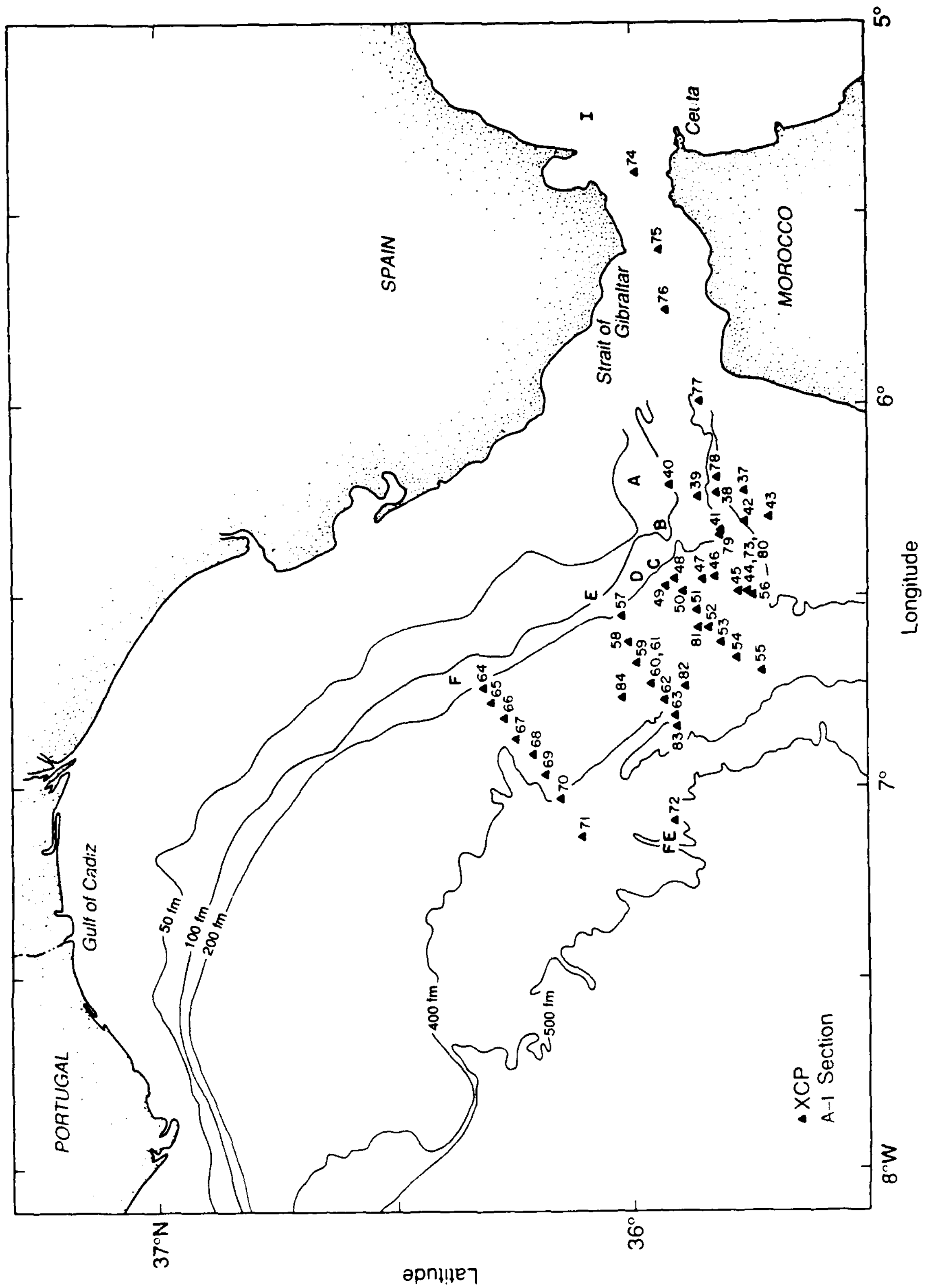

Figure 29. XCP drops, sections A–I.

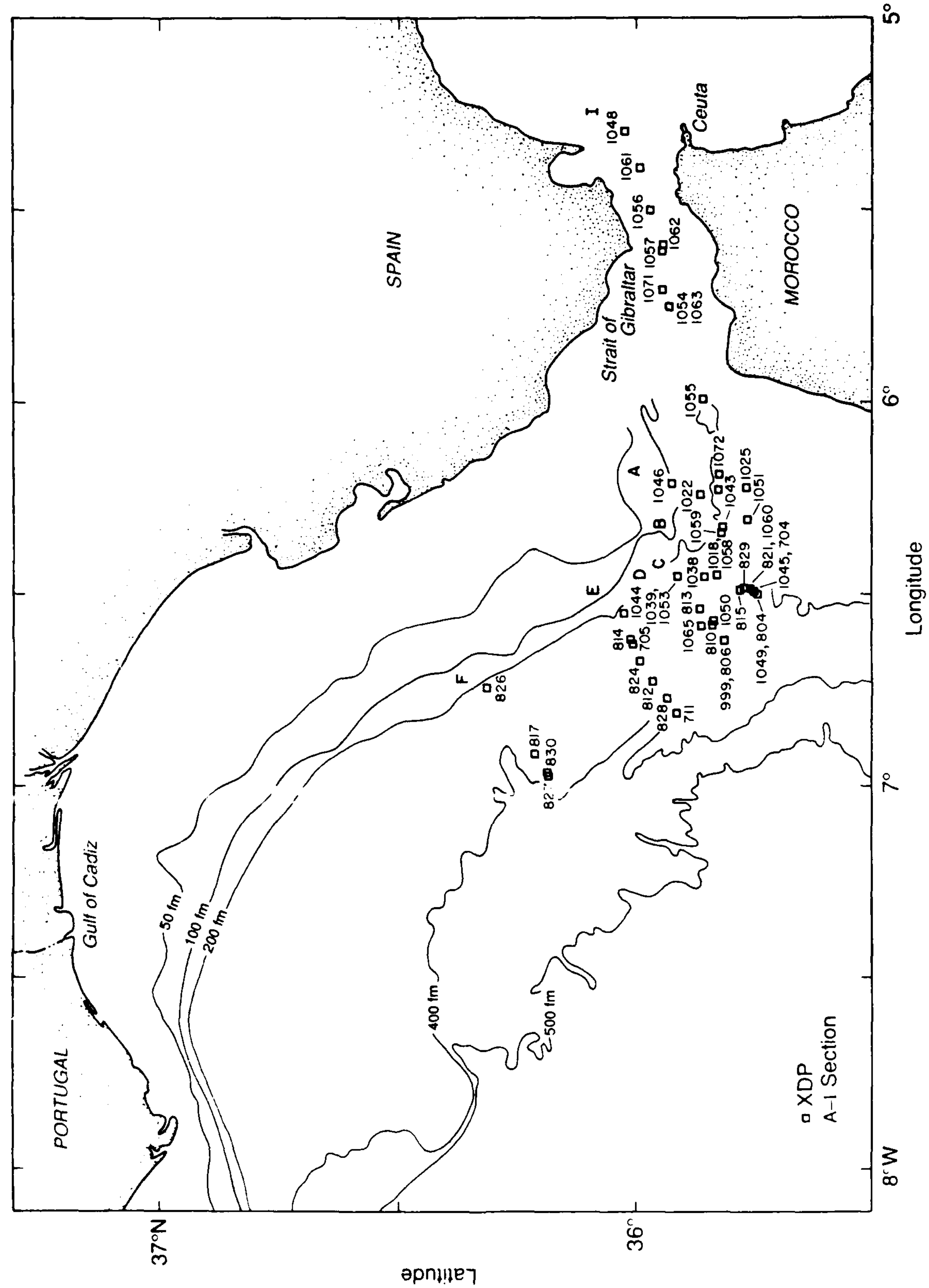

Figure 30. XDP drops, sections A–I.

4. DATA PROCESSING

4.1 Drifters

The drifter tracks (Figures 31–36) were derived from the ship's position when the ship was alongside each drifter. There were seven deployments (Table 2). The first four were on the NW, NE, SW, and SE corners of the summit of Ampere Seamount approximately 7 km from the navigational radar mooring (Figure 6). Drifter 3 lost its command receiver and drag line, so its rapid movement to the south may have been due to windage on the surface float. Drifters 1 and 2, deployed above the north flank of the seamount, moved off to the east at approximately 6 cm s^{-1}. Drifter 4 (deployed east-southeast of the summit) moved little before 8 September, suggesting that it may have been near a stagnation point. During 8 September, drifter 4 began moving south at approximately 9 cm s^{-1} as did drifters 6 and 7 on the eastern flank of the seamount. Individual tracks are not shown for drifters 1 and 3 since their movement can easily be seen in Figure 31.

4.2 XCP, XBT, and XSV Drops

To combine data from expendable probes (such as XBTs, XSVs, and XCPs) with CTD data for contouring and computing heat and salt transports, the depth needs to be calibrated against a standard. For the expendable probes used in this experiment, the depth (and thus the fall rate) of the probe is estimated as a quadratic function of time. The coefficients of the quadratic polynomial are empirically determined by Sippican Inc., the manufacturer of the probes. During the Gulf of Cadiz experiment, we had an opportunity to verify the depth estimates of the probes by comparing the high-wavenumber structure of their temperature or sound velocity signal with that obtained by the Sea-Bird CTD unit. This process also gave us information about the random errors and systematic offsets in these variables. This section summarizes the computational procedure and presents the results. An additional comparison was made between the XSVs and the XBTs, since the data from these probes can be combined to estimate salinity.

Because the CTD's vertical reference is pressure and the expendable probe's reference is depth, a conversion is needed before the expendable probe's depth can be calibrated. Saunders and Fofonoff (1976) present a conversion method that consists of integrating the hydrostatic equation downward from the sea surface, while accounting for

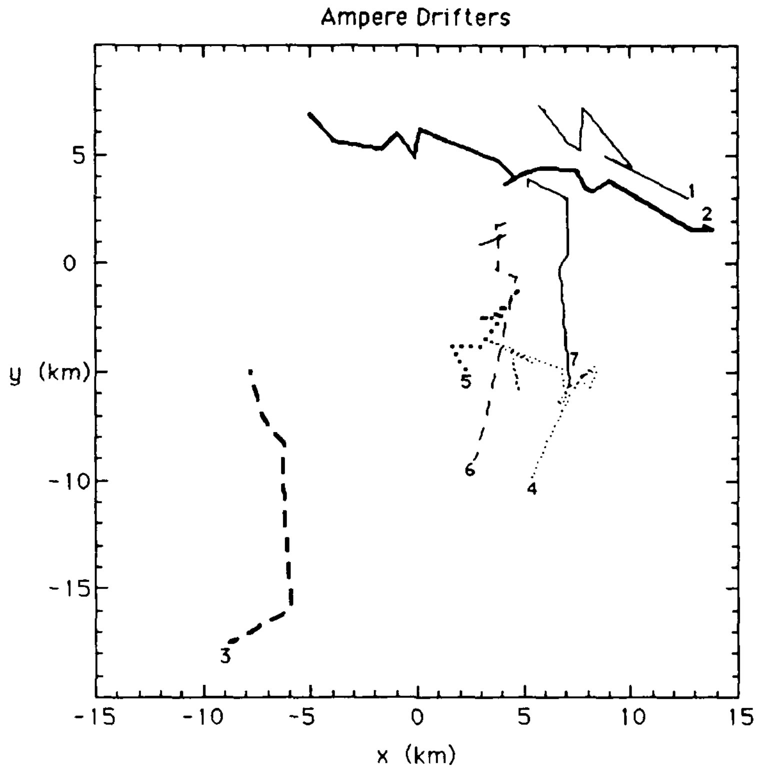

Figure 31. Tracks for drifter deployments 1–7.

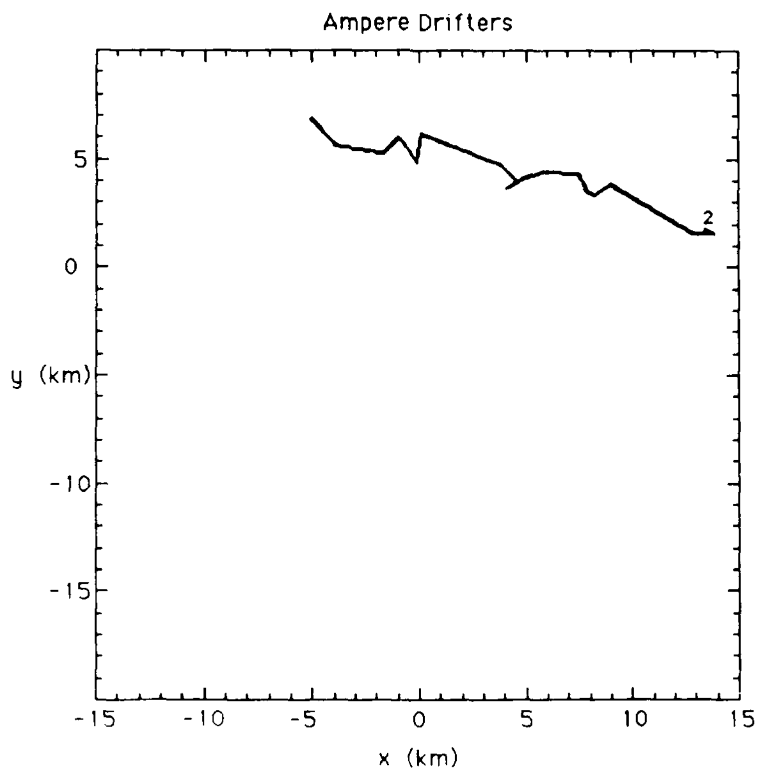

Figure 32. Track for drifter deployment 2.

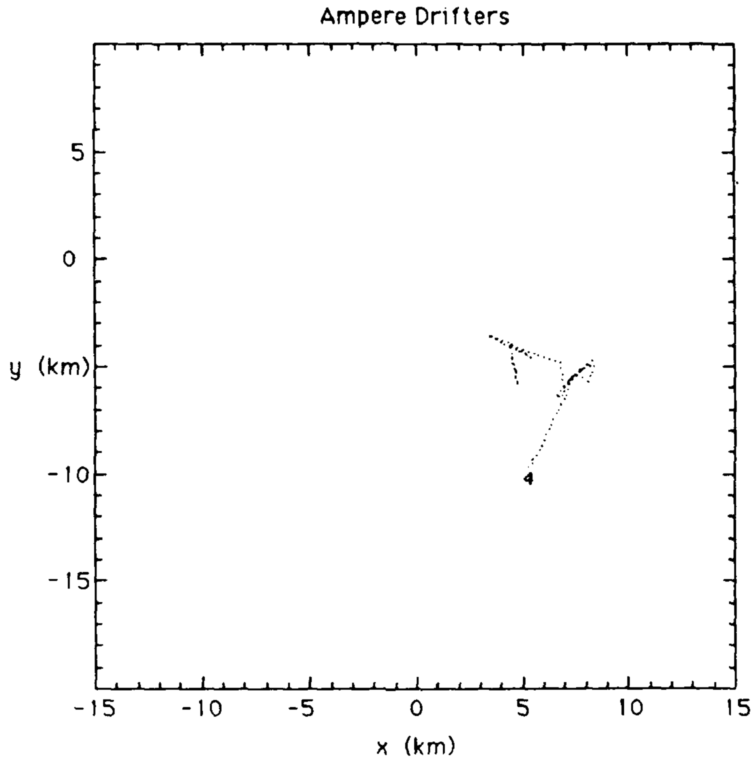

Figure 33. Track for drifter deployment 4.

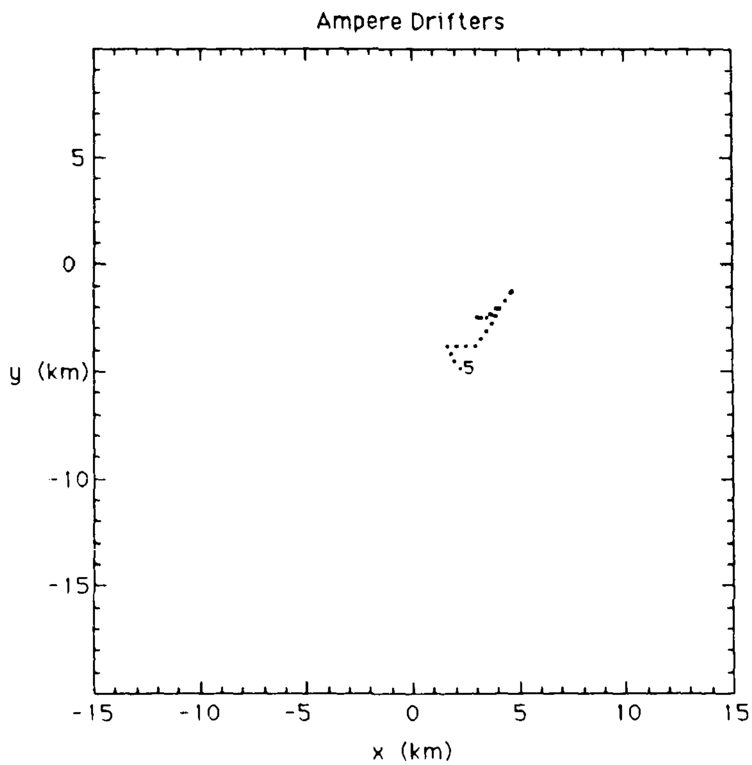

Figure 34. Track for drifter deployment 5.

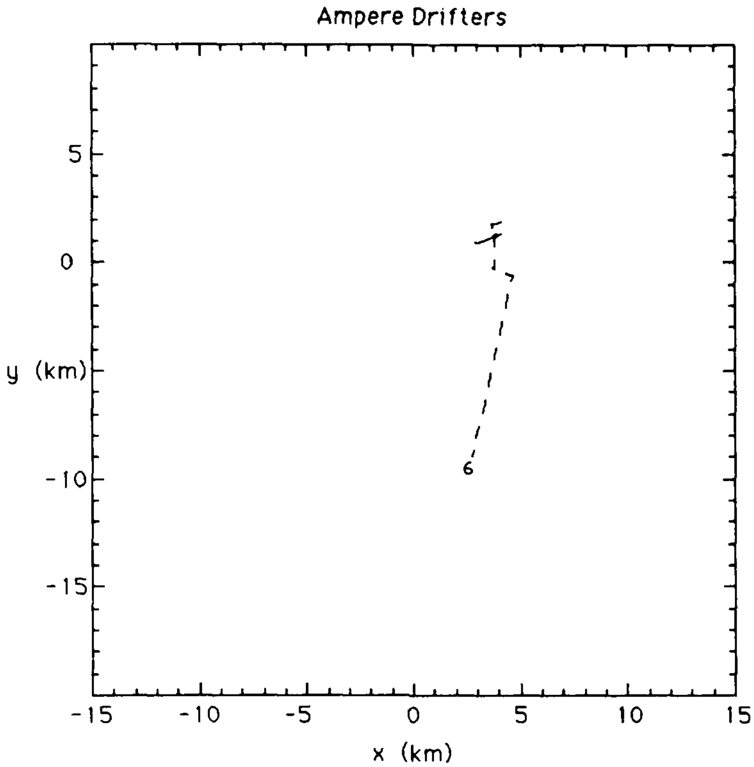

Figure 35. Track for drifter deployment 6.

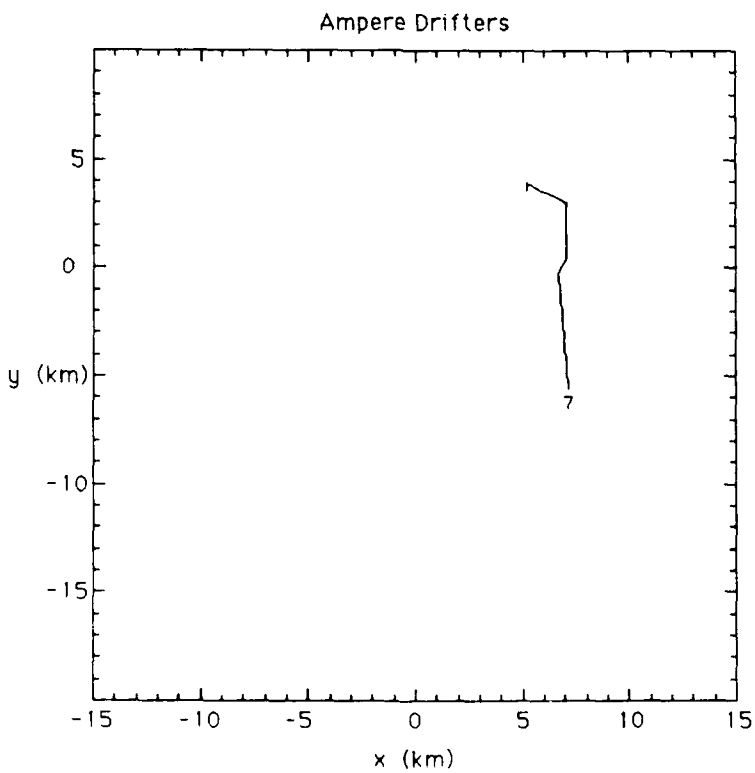

Figure 36. Track for drifter deployment 7.

the horizontal and vertical variations in the earth's gravitational field. For this analysis, the CTD data collected on the cruise were averaged into 10-dbar bins, and the vertical integration was performed for each cast. At each bin level, a ratio was formed between the computed depth (in meters) and the measured pressure (in decibars). The resulting ratio-pressure curves from all the casts were combined at each bin level to give a curve for the average ratio. An approximation to the average ratio curve is given by

$$\text{ratio}(\text{pressure}) = 0.9927 - 2.55\times10^{-6}\,\text{pressure} + 0.0073\exp(-\text{pressure}/50)\,.$$

Figure 37 shows the average ratio curve (steppy) and the approximate curve (smooth). The depth is found by multiplying the measured pressure by the ratio appropriate for that pressure. Thus when the pressure is 1000 dbar, the corresponding depth is 1000×0.9901, or 990.1 m. The maximum error in depth caused by using the approximate curve instead of the one for any particular CTD cast is about 0.5 m. Pressure and depth will be used interchangeably in this section, but with the understanding that the appropriate conversions have been made.

Software was then developed to determine the relative depth offset as a function of depth between two drops or casts, assuming the instruments passed through similar ocean features on their descent. The vertical scales of the features used to compare the depths were between 10 and 100 m. To accent these features, the signal from the probe (either temperature or sound velocity) was bandpass filtered to remove very-high-wavenumber noise and low-wavenumber features. The program then shifted one profile with respect to the other and found the depth offset that maximized the correlation of the two over a limited depth range. This process was repeated for each depth value in the drop. Rather than compute the correlation for every offset possible, a "golden section search" (Press *et al.*, 1986) was performed to find the maximum correlation. The correlation was assumed to be a smoothly varying function of offset, with a global maximum at the optimal offset. The optimized search procedure gave results comparable to the point-by-point search and ran 5 to 10 times faster. The maximum correlation achieved and the corresponding depth offset were recorded, as well as the temperature or sound velocity differences in the nonfiltered signals at the optimum offset. Figure 38 shows an example of the program output for an XSV/XBT drop pair.

After a depth offset record was obtained for all the expendable probes, a second program computed the mean and rms of the depth offset and the signal difference. During many drops, the maximum correlation at a depth bin was below 0.5, lowering the confidence that a good estimate of the depth offset and signal difference was obtained. To keep these values from being included in the average and contributing to the rms value, if the maximum correlation obtained for each depth bin during a drop was below a user-defined minimum (usually 0.9), the depth offset and signal difference were not included in the subsequent calculation.

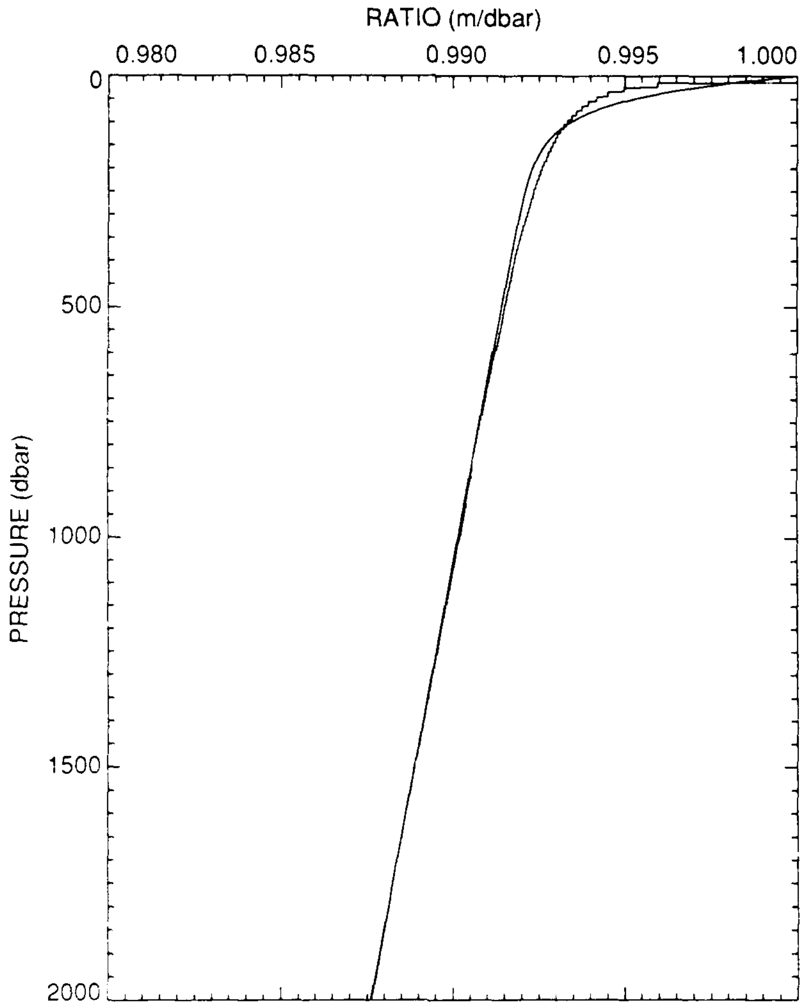

Figure 37. Relation between pressure and depth derived from the vertical integration of CTD data. The steppy curve is the integrated value, and the smooth curve is a fit to the data.

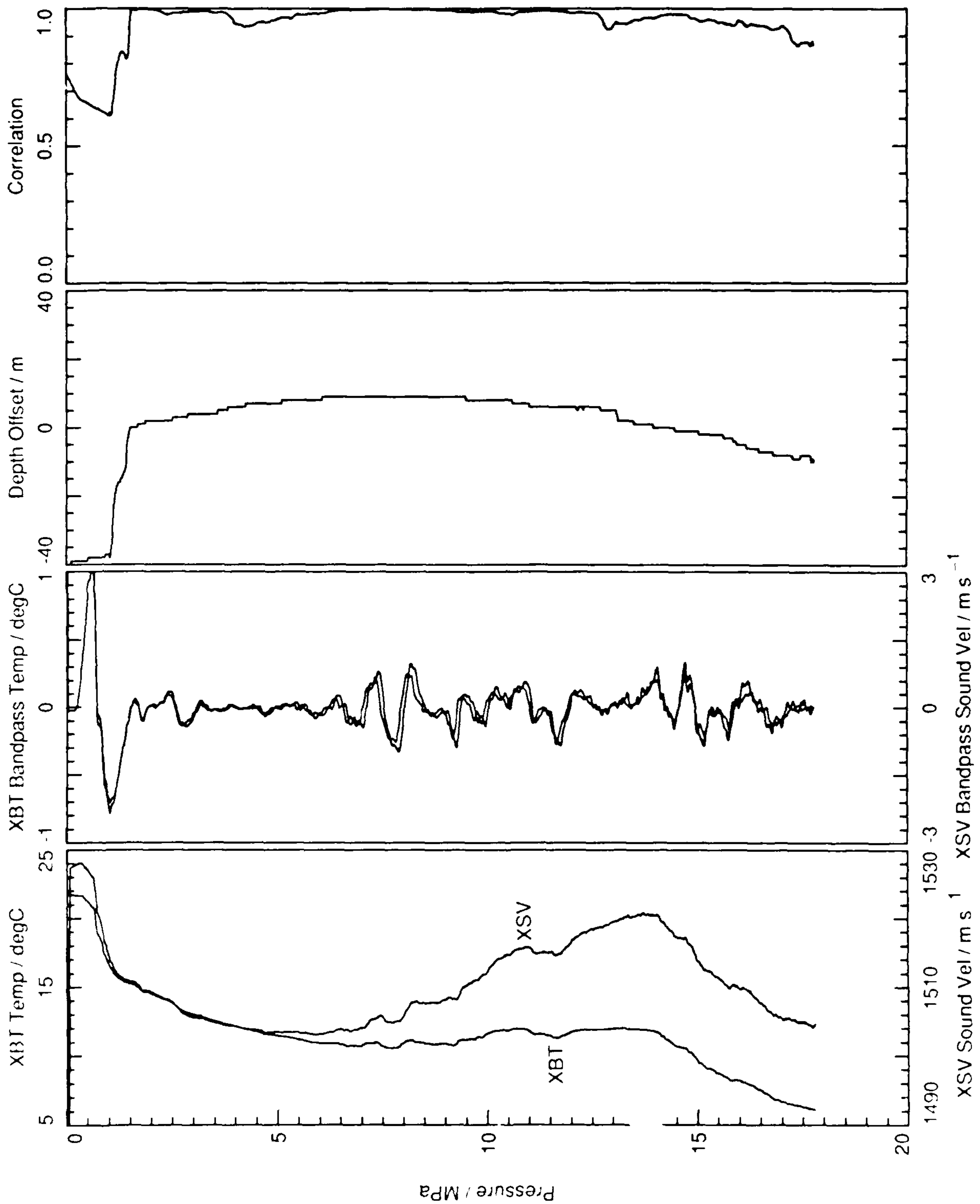

Figure 38. Output of program comparing an XSV/XBT drop pair.

A probe/CTD pair was considered acceptable for analysis if the processed data from the probe passed a visual inspection (no noticeable offsets, spikes, wire breaks, etc.) and the probe was dropped within 1 hour and within 1 n.mi. (2 km) of the CTD cast. These temporal and spatial constraints may appear harsh, especially compared with a previous error analysis by Heinmiller *et al.* (1983) which used XBT/CTD pairs 15 to 50 km apart; however, because of the complex structure and interleaving of the Mediterranean outflow in the Gulf of Cadiz, small differences in time or position severely degraded the signal correlations.

There are 65 XCP/CTD pairs; the majority (47) occurred during the second leg of the cruise while the ship was in relatively shallow water (less than 500 m). The analysis was separated into deep drops and shallow drops, which were then recombined to give the final results. The XCPs were typically dropped immediately after leaving a CTD station. This process led to spatial separations of up to 1 n.mi. and temporal separations of up to 1 hour. When a high correlation was imposed on the mean and rms computations, the number of accepted values was much smaller than the number of drop pairs. By chance, the processing software used at sea for the Cadiz cruise did not use the depth coefficients for the Mod 7 XCPs, but rather the coefficients for earlier models. The Mod 7s supposedly fall about 0.3 m s^{-1} slower than earlier models. Because the depth of the probe is computed from the elapsed time after launch, the depth coefficients would reflect this difference in fall rate. However, the offset between the depths calculated for the XCP drops when using the earlier depth coefficients and those obtained from the CTD data was usually less than 5 m, even at 1600 m. Where the earlier coefficients placed the probe at 1600 m, the Mod-7 coefficients gave a depth 90 m shallower. Table 5 lists the depth coefficients used for the Mod 7 and the earlier models. It is not known yet what effect the unique temperature and salinity structures in the Mediterranean outflow may have on the XCP fall rates.

Table 5. XCP fall rate coefficients.

Coefficient	Mod 7	Earlier Models
pcal0	4.875	3.1
pcal1	4.276	4.544
pcal2	−0.00063	−0.0006749

A nearly linear trend was observed in the temperature difference between the XCPs and the CTDs, with the XCPs being 0.05°C warmer at the surface and 0.25°C warmer at 1600 m. It is unknown whether the trend was due to a pressure effect on the thermistor and circuitry or to a temperature effect on the circuitry alone. The rms temperature variation between the XCPs was 0.1°C. Further work is needed to determine the source of the temperature offset, perhaps by analyzing XCP/CTD pairs from other cruises where the temperature and salinity structure is substantially different than in the Gulf of Cadiz.

Four T-5 XBT/CTD pairs, one T-6 XBT/CTD pair, and one T-7 XBT/CTD pair were used in this analysis, but did not provide enough comparisons to estimate the depth offsets accurately. However, a systematic mean temperature offset of 0.075°C was observed throughout the drops, with a rms temperature variation of less than 0.1°C. The accuracy of the probe is given by Sippican Inc. as ±0.15°C.

Three XSV-02/CTD and two XSV-03/CTD pairs were used in this analysis. During the cruise, it was noticed that features in the XSV data were roughly 8% shallower than similar features in the XBT or CTD data. No more accurate estimate could be made at the time because of the small number of pairs. A better estimate of the depth offset is made later in this section. The analysis showed a 0.20 m s^{-1} offset in all the sound velocities. The sound sensor is probably the same for all the XSV probes, so the same offset is expected for both types of XSVs. The accuracy of the probe is given by Sippican Inc. as ±0.25 m s^{-1}.

The XSV-02/XBT(T-5) drops give the highest quality comparisons, primarily because the two probes were dropped simultaneously, with a spatial separation of 10 m (the width of the fantail). XSV depths were multiplied by 1.08 before processing to partially correct the depth offset noticed on the cruise and to reduce the search for the maximum correlation. The results show the rms offset varies linearly with depth, from 1 m rms at the surface to 6 m at 1500 m depth. Table 6 gives the fall rate coefficients computed from this analysis.

For processing the Cadiz cruise XCP data, we recommend using the XCP Mod 6 depth coefficients, subtracting 0.05°C from the surface temperatures and 0.25°C from the 1600-m temperatures, and applying a linear correction between these depths. This

Table 6. XSV fall rate coefficients.

Coefficient	Sippican	1.08 × Sippican	Cadiz Cruise
pcal0	0.0	0.0	3.38
pcal1	5.5895	6.0367	5.8561
pcal2	−0.00147	−0.00159	−0.000883

analysis assumes that the XBTs have the correct fall rate which, given the limited data, is the only assumption possible at this time. Subtracting 0.075°C from the type T-5 XBT temperatures is recommended. The Cadiz cruise depth coefficients are recommended for any XSV-02 processing, along with adding 0.2 m s^{-1} to the sound velocities. Because of the limited data for XSV-03s, their depths have been assumed to be correct.

4.3 CTD Data

Seasoft version 3.0, dated 23 May 1988, written by John Backes at Sea-Bird Electronics, was used for CTD data acquisition. Data were acquired on the down cast only.

In the Seasoft 3.0 SEASOFT.CFG file, the number of scans to average in the deck unit was set to 24 (i.e., 1 s). This was done by running the SEACON program. Further averaging was done with respect to pressure, in 10-dbar bins, using the Seasoft 3.0 BINAVG file for all CTD casts during the cruise.

Water samples were taken by attaching a single 1.5-liter Niskin bottle to the electromechanical wire supporting the Sea-Bird CTD underwater unit.

Marker files, Seasoft version 3.0 CTD###.MKR files, were created on the COMPAQ computer at the beginning and end of the Niskin bottle soak time for later comparison with salinity values determined by the Guildline Autosal salinometer. The marker files include time, date, pressure, temperature, salinity, density, sound velocity, and scan number.

The individual water samples were collected from the Niskin bottle using glass citrate of magnesia bottles supplied by the Physical and Chemical Oceanographic Data Facility at Scripps. The bottle and seal were flushed twice before drawing the final sample. Replicate samples were taken for CTD stations 50 through 148. The samples were

stored for at least 24 hours in the laboratory next to the Autosal to stabilize their temperature. The Autosal was calibrated using standard Wormley seawater during the first few days of the cruise after the bath had initially stabilized. Six separate batches were run on the Autosal. The two conductivity ratios for each sample were averaged for use in computing salinity.

Wormley water batch number P108 was used for all Autosal standardizations. The K_{15} value was 0.99980 and the chlorinity 19.371. The raw salinity of this water was calculated to be 34.994 psu, using the IEEE algorithm (Lewis, 1980). Averaged conductivity ratios for each water sample, determined with the Guildline Autosal, were used to correct the raw salinity values.

An offset between the Autosal salinity values and known standard seawater values was found for runs 4, 5, and 6. The formula (standard water salinity initial value, in psu) – (34.994 psu) was used to determine the offset for each run. The drift throughout the individual runs was calculated also. The drift per sample was found using the formula [(standard water salinity final value, in psu) – (standard water salinity initial value, in psu)] / (number of samples + standards – 1). These values are summarized in Table 7. Because replicate samples were taken only for stations 50–148, only those samples were used in comparing the SBE CTD salinity values and the Guildline Autosal salinity values.

The replicate salinity samples from the Niskin bottle for stations 50–148 were logged and stored in the main laboratory aboard R/V *Oceanus* for transport to the Woods Hole Oceanographic Institution. Marv Stalcup at WHOI analyzed the replicates using another Guildline Autosal.

Table 7. Salinometer run information.

Run Number	CTD Stations	No. of Samples	Std Water Initial Salinity (psu)	Std Water Final Salinity (psu)	Offset Per Run	Drift Per Sample
4	50–92	24	35.0216	35.0276	0.02760	0.000240
5	93–116	19	35.0198	35.0277	0.02580	0.000395
6	122–148	13	35.0161	35.0229	0.02210	0.000486

Comparison of the salinity values calculated with the *Oceanus* Autosal and the replicate values calculated with the WHOI Autosal showed a mean difference of −0.0003 psu with a standard deviation of 0.0084. Five of the 55 samples collected on casts 50–148 were not used in the calculation because of large differences between the Sea-Bird and Autosal measurements. These differences result from sampling in an area of high vertical gradients.

An average difference of −0.0089 psu with a standard deviation of 0.0096 was calculated for the same set of samples when comparing Autosal seawater salinity measurements performed on the R/V *Oceanus* with the Sea-Bird Seasoft version 3.0 marker file salinities. Also, an average difference of −0.0092 psu with a standard deviation of 0.012 was calculated for the same set of samples when comparing Autosal seawater salinity measurements performed at WHOI with the Sea-Bird Seasoft version 3.0 marker file salinities. These results are summarized in Table 8.

Table 8. Sea-Bird CTD salinities (version 3.0 software) versus corrected Autosal salinities.

	ΔS_1 (SB–SC) (psu)	ΔS_2 (SB–WA) (psu)	ΔS_3 ($\Delta S_2 - \Delta S_1$) (psu)
Average	−0.0089	−0.0092	−0.0003
Standard Deviation	0.0096	0.012	0.0084

SB = Sea-Bird salinity (version 3.0)
SC = Ship's Autosal, corrected salinity
WA = WHOI Autosal, corrected salinity

During and after the cruise, there was concern about the offset between the Autosal and Sea-Bird salinities. John Backes of SBE looked into the residual difference after initial Autosal correction factors were applied, and found that the compressibility of the conductivity cell needed to be compensated for in the software. SBE Application Note No. 10, dated October 1988, was written to document the updated version of Seasoft, now version 3.2, which automatically implements a compression compensation equation.

To test this new software, Backes and Tom Lehman ran the bin-averaging routines in both Seasoft 3.0 and Seasoft 3.2 using the same data set for CTD 12. They found that

the new software with its pressure-dependent term changed the computed salinity at the bottle sampling depth, 2010 dbar, from 35.189 psu to 35.197 psu, a change of 0.008. The increase in salinity when using Seasoft version 3.2 was in the right direction to offset the difference. The next step was to compute salinities with version 3.2 and compare them with the corrected Autosal values. This was done for a subset of the data, 24 stations. Both precruise and postcruise calibrations were tried at this stage. The results are summarized in Table 9. The salinities computed using the postcruise calibrations agreed well (within the stated accuracy of ±0.002 psu for the Guildline Autosal model 8400A) with the corrected Autosal salinities and were used in all subsequent reprocessing.

All the data from *Oceanus* Cruise 202 were reprocessed using the postcruise calibrations and version 3.2 of Seasoft, producing pressure, temperature, and conductivity values in 2-dbar bins. Derived quantities (e.g., salinity, density, etc.) were calculated using seawater routines written by Ngoc Dang at APL.

Table 9. Sea-Bird CTD salinities (version 3.2) versus corrected Autosal values.

	$(SB_{pre} - SC)$ (psu)	$(SB_{post} - SC)$ (psu)
Average	−0.0083	−0.0019
Standard Deviation	0.0088	0.0089

SB = Sea-Bird salinity (using version 3.2)
SC = Ship's Autosal, corrected salinity

4.4 Navigation

The Loran-C, differential Omega, and Transit/dead-reckoned data were processed separately by similar averaging programs which provide positions on a uniform time grid. The time grid usually has a 60-s interval. Position data are averaged over 60 s and velocity data over 300 s. Grid times when no data are available or when the programs sense abnormal data have a "bad value" flag.

The differential Omega and Transit/dead-reckoned positions are decoded and averaged using least-squares techniques to get the average position and rate of change, i.e., the velocity over the ground.

The average and rate of change of the Loran-C travel times are also computed, using the same least-squares techniques. These values are then converted to position and velocity over the ground, using standard Loran-C conversion equations.

The Transit satellite fixes are used to keep the range-range Loran-C position error from increasing without bound as the shipboard rubidium clock drifts. This also removes the differences in emission times between the two chains.

The difference between the travel time measured by Loran-C to each station and the expected travel time based on the position determined by the satellite fix provides a clock error at each fix time. This error was plotted and graphically fit by eye to a straight line to provide clock drift and offset over periods of several days to a week.

The corrections were made to a resolution of 1 μs, since the rms travel time noise was about 1 or 2 μs. Thus ranges to the stations are no better than 300 m. If more accuracy is desired, more effort could profitably be put into these clock drift and offset calculations.

We used only satellite fixes that had elevation angles between 15° and 70° and that were not rejected by the MX-1103. This screens out many bad fixes but not all.

Early in the cruise, the Loran-C sets would periodically lose the weak signals and automatically reacquire them sometime later, so the clock offset would need to be recalculated. The offset could not be computed as accurately when the set stayed locked for only a few satellite fixes because of the large variability. The drift was assumed to remain the same during those periods.

The satellite fixes are also used to correct lane jumps in the Loran-C sets and the propagation delays (additional secondary phase factors) not corrected by the simple over-water propagation model used in the program.

There is a strong diurnal character to the quality of the Loran-C data. It is much better during the day than at night. The rms variability over a 1-min average of the Loran-C travel times ranges from 100 to 200 ns at night to as little as 30 ns during the day.

A problem uncorrected to date is that the HP-UX computer time was in error by almost 2 min by the end of the cruise. It had been set at the beginning and allowed to drift. When the Transit fixes are compared with the Loran-C data to obtain the clock bias

and drift, this time error introduces a position error of as much as 600 m when the ship is moving at 10 kn. This may account for part of the rms variability between the Transit fixes and the Loran-C positions. Sufficient data were recorded to correct for this problem.

The decision of which stations to include in the position determination was fairly straightforward later in the cruise. All four of those mentioned were used. Earlier in the cruise, including the Mediterranean chain in the calculations seemed to give poorer results. This was determined by examining the ship's tracks obtained when using various stations. During the XCP surveys over Ampere Seamount, the smoothest ship track was obtained when only the two French stations were used.

Unfortunately, there were times when one of those stations was not available, so the Mediterranean stations had to be used to obtain any Loran-C positions at all.

5. OBSERVATIONS AND RESULTS

5.1 Ampere Seamount

5.1.1 Mooring

The mean position of the radar mooring determined using Loran-C data was 12°52.3'W (±1 km), 35°03.3'N (±0.5 km). The greater errors in the east-west position are due to Loran-C noise. The Omega data appear to contain the same noise. There was a standard deviation of 0.25 km in the satellite fix positions.

5.1.2 XCP Survey 1

Figure 39 is a plot of current speed versus depth as determined from XCP drops 2429–2442 (except 2431 and 2440) for leg 1 of the second Ampere Seamount survey. The nominal spacing between consecutive drops was 500 m. A mid-depth (1100–1400 m) mean was removed from each drop before the speed was computed. The first drop is plotted to scale, and each successive drop is offset 10 cm s^{-1}. The drop spacing used during this survey produces good correlation between adjacent profiles yet resolves features (for example, the feature centered around 650 m) well enough to show changes from the beginning to the end of the survey.

5.2 Meddy Component

The inset in Figure 40 shows the velocity vectors at mid-depth (≈1050 m) of the Meddy surveyed during this cruise. The core of the Meddy out to 8 km is in near-solid-body rotation, with $\zeta / f \approx -0.9$, where ζ is the relative vorticity and f the planetary vorticity. This Meddy appears to have a low-order axial asymmetry.

5.3 Outflow Experiment

Figure 41 is a plot of u velocity (cm s^{-1}) versus depth as determined from XCP drops in and west of the Strait of Gibraltar (inset). Shading indicates regions where $u < 0$. The leftmost drop is plotted to scale; each successive drop is offset 100 cm s^{-1}. Each probe operated until it hit the seafloor. Note evidence of a bottom boundary layer (BBL) which tends to bring the velocity to zero at the seafloor. Processing with higher vertical resolution will exhibit the BBL more clearly and permit the estimation of u^*, the friction velocity.

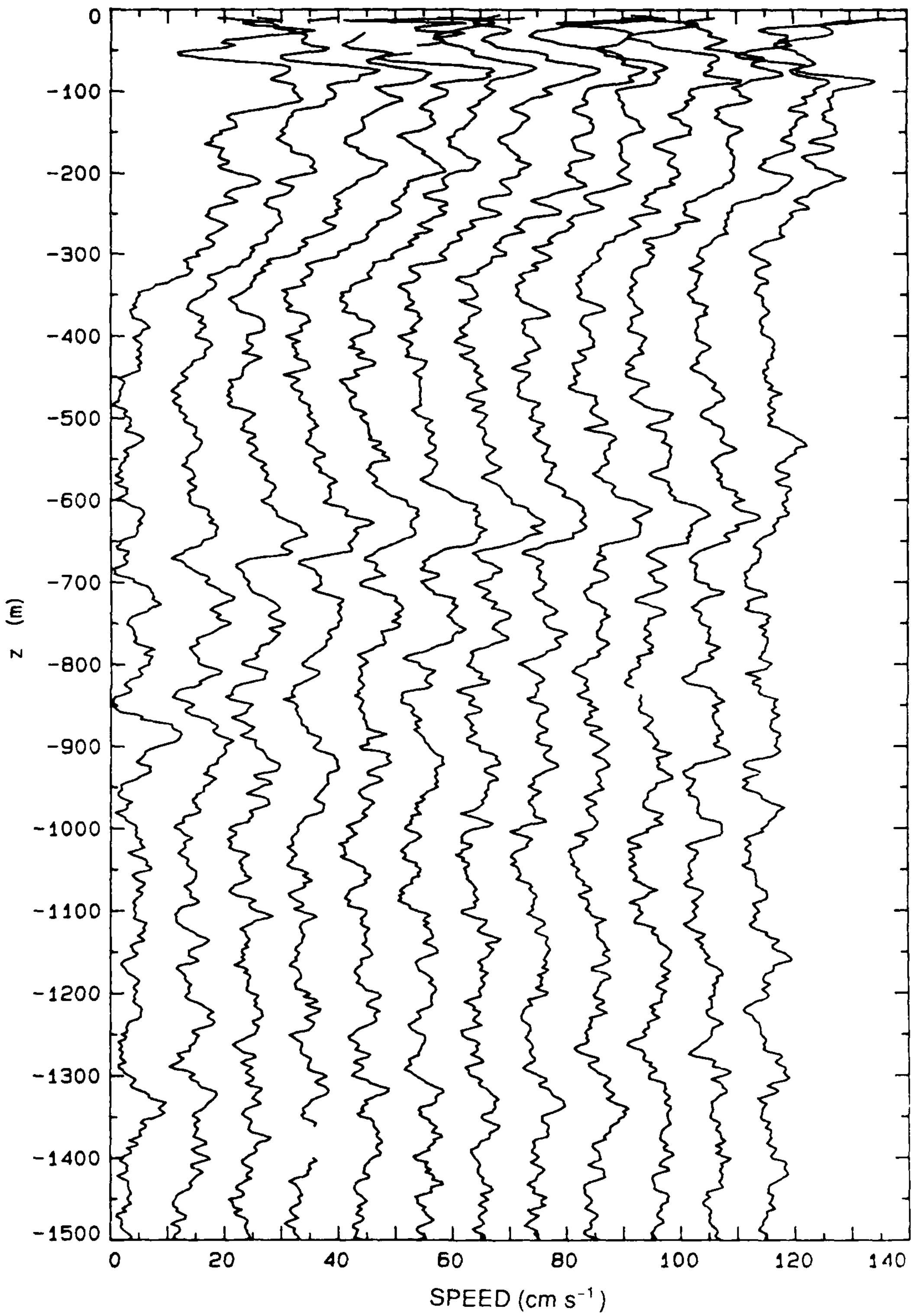

Figure 39. Plot of current speed versus depth as determined from XCP drops 2429–2442 (except 2431 and 2440) during leg 1 of the second Ampere Seamount survey. These profiles are based on at-sea processing.

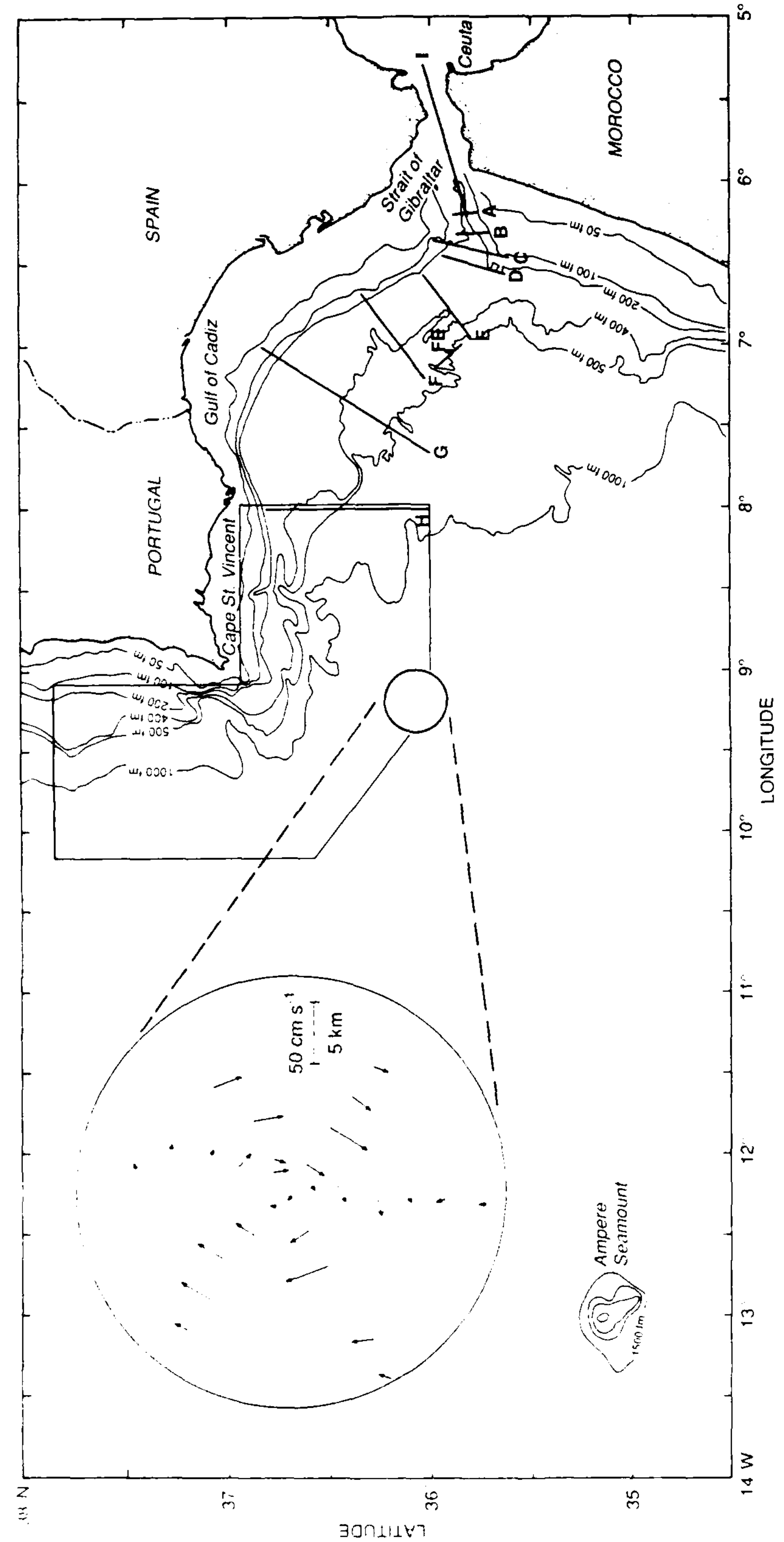

Figure 40. ***Velocity vectors at mid-depth (≈1050 m) of a Meddy (inset). The scale above the plot shows length of 50 cm s^{-1} vector.***

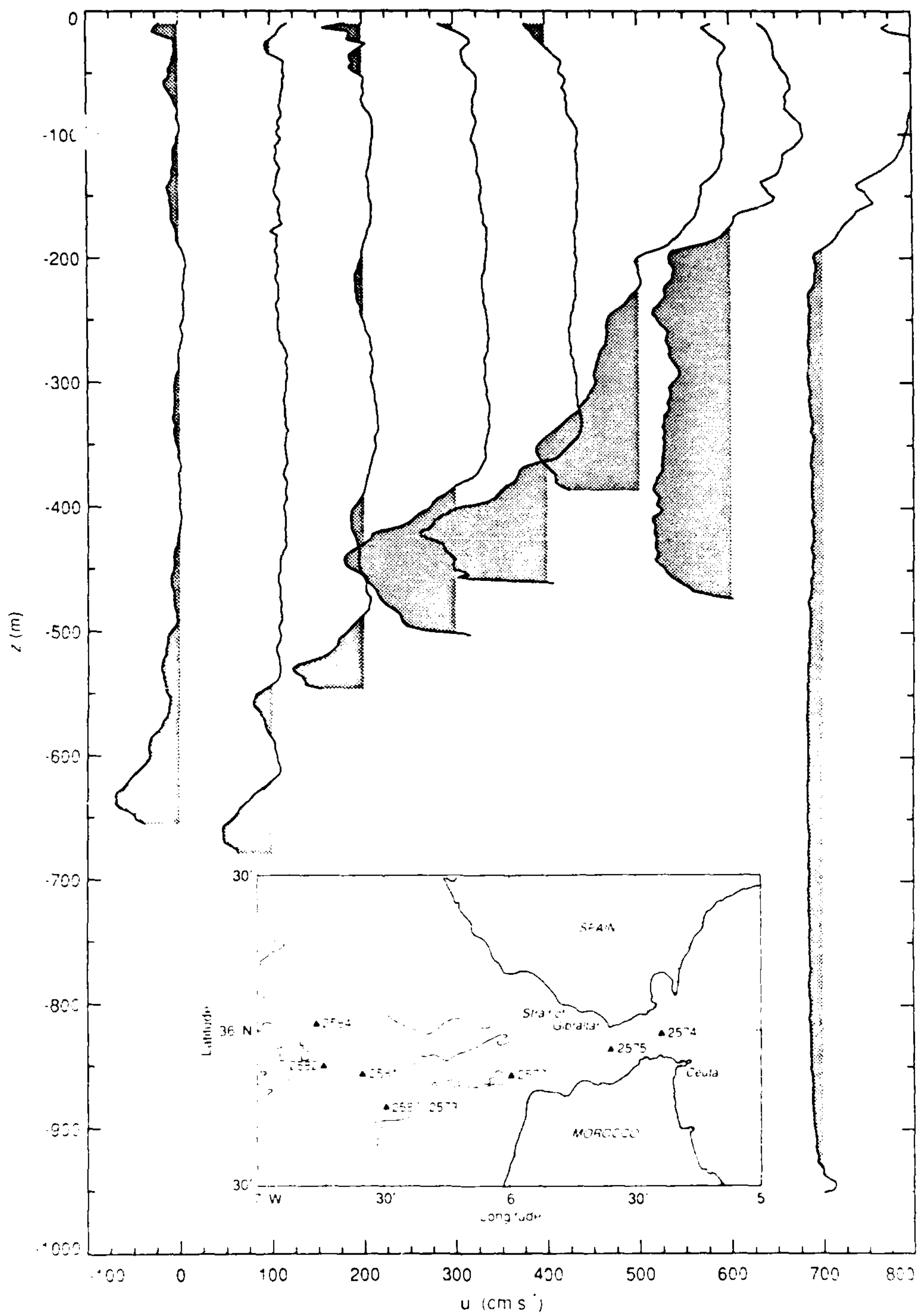

Figure 41. Plot of u *velocity (cm* s^{-1}*) versus depth from XCP drops in and west of the Strait of Gibraltar. Shading indicates regions where* u < 0*. The leftmost drop is plotted to scale; each successive drop is offset* 100 *cm* s^{-1}*.*

5.4 Navigation: Which System Provides the Most Accurate Positions?

Ship tracks obtained from Loran-C, differential Omega, and Transit/dead reckoning were plotted for the XCP surveys near Ampere Seamount as well as for the Meddy survey. The peak-to-peak variability over several miles of track is about 200 m or less for the Loran-C data and about 600 m for the differential Omega data. There are times when the Omega track deviates by several miles from both the Loran-C and Transit/dead-reckoned tracks. The Transit/dead-reckoned tracks occasionally jump several miles when new satellite fixes arrive.

The Loran-C seems to provide the best position data for use in computing short-term differences in position. There can be some errors in long-term differences because the various combinations of stations have not been adjusted for minimum offset. There is also a jump in position when switching to a new combination of stations. This could be adjusted with more effort, but this adjustment has not been attempted for this data set. These position jumps could have some effect on the velocities computed for the floats. An attempt was made to keep the station suite constant during each XCP survey.

In an attempt to decide which positions were best, the rms error in the positions calculated by the three methods was computed for each day of the cruise. These data are shown in Table 10. The offset between the differential Omega and Transit/dead-reckoned positions is generally 1500–2000 m, rising to 2800 m on several days. For 4–5 September, the difference between the Loran-C positions and those calculated by the other two methods exceeded 2000 m; after that, the Loran-C and differential Omega positions differed by 1000–2000 m. The difference between the Transit fixes and the Loran-C data is about 1000 m rms (Figure 42). It seems that the Loran-C data are the best for 7 September and later. The GPS data would have been very valuable in deciding which of the systems gave the most accurate positions.

The Loran-C data have been used as the primary position data for the whole cruise except for isolated times when there were no Loran-C data; in that case, the differential Omega data were used or, if they were not available, the Transit/dead-reckoned data.

Table 10. *Standard deviations of position differences between Loran-C, differential Omega, and Transit/dead reckoning for 4–28 September 1988. Values are in meters.*
x = East component; y = North component; sm = standard deviation about the mean; st = total rms error including the mean error, i.e., sqrt(mean × mean + sm × sm).
lc = Loran-C; om = Differential Omega; dr = Transit/dead reckoning

date 1988	x sm lc-om	x sm lc-dr	x sm om-dr	y sm lc-om	y sm lc-dr	y sm om-dr	xy sm lc-om	xy sm lc-dr	xy sm om-dr	xy st lc-om	xy st lc-dr	xy st om-dr
0904	1664	2153	1258	1436	1653	866	2198	2715	1527	2687	2803	1789
0905	2306	2404	1417	1648	1590	758	2934	2882	1607	2853	2899	1713
0906	1503	1359	1017	1318	1501	946	1999	2025	1389	2020	2032	1465
0907	938	1008	1461	760	775	742	1207	1272	1638	1424	1280	1670
0908	1639	1088	1614	617	667	752	1751	1276	1780	1941	1418	1796
0909	2394	657	2522	544	963	1029	2455	1165	2724	2489	1202	2808
0910	1434	801	1713	576	836	1004	1545	1158	1986	1836	1241	2195
0911	630	728	732	332	637	637	712	967	971	949	1115	1013
0912	762	899	1107	322	677	624	828	1125	1271	1029	1187	1339
0913	406	1152	1187	277	1010	978	492	1532	1538	[illegible]	1674	[illegible]
0914	8775	1223	8516	662	1120	1296	8800	1711	8614	9403	1751	9274
0915	327	1087	1211	321	923	1038	980	1415	1595	1142	1490	1664
0916	644	1256	1265	260	802	812	695	1490	1503	901	1573	1814
0917	922	720	1050	352	748	827	987	1038	1337	1063	1154	1435
0918	2253	1067	2444	758	677	961	2377	1263	2626	2622	1290	2854
0919	843	1092	1343	321	1407	1475	902	1781	1995	1879	1831	2841
0921	749	956	1227	303	540	614	805	1098	1372	1593	1121	2097
0922	1043	1606	1563	460	765	792	1146	1779	1752	1597	1737	1943
0923	848	879	1052	407	756	961	940	1159	1425	1125	1193	1600
0924	740	746	896	360	693	753	823	1016	1174	1075	1036	[illegible]
0925	672	1353	1439	252	511	596	718	1446	1557	861	1476	1744
0926	[illegible]	1194	1075	265	[illegible]	830	562	1396	1354	831	1441	1641
0927	[illegible]	2183	2294	373	923	979	1645	2374	2444	2183	2443	[illegible]
0928	[illegible]	941	1401	[illegible]	378	394	1111	[illegible]	1455	[illegible]	[illegible]	[illegible]

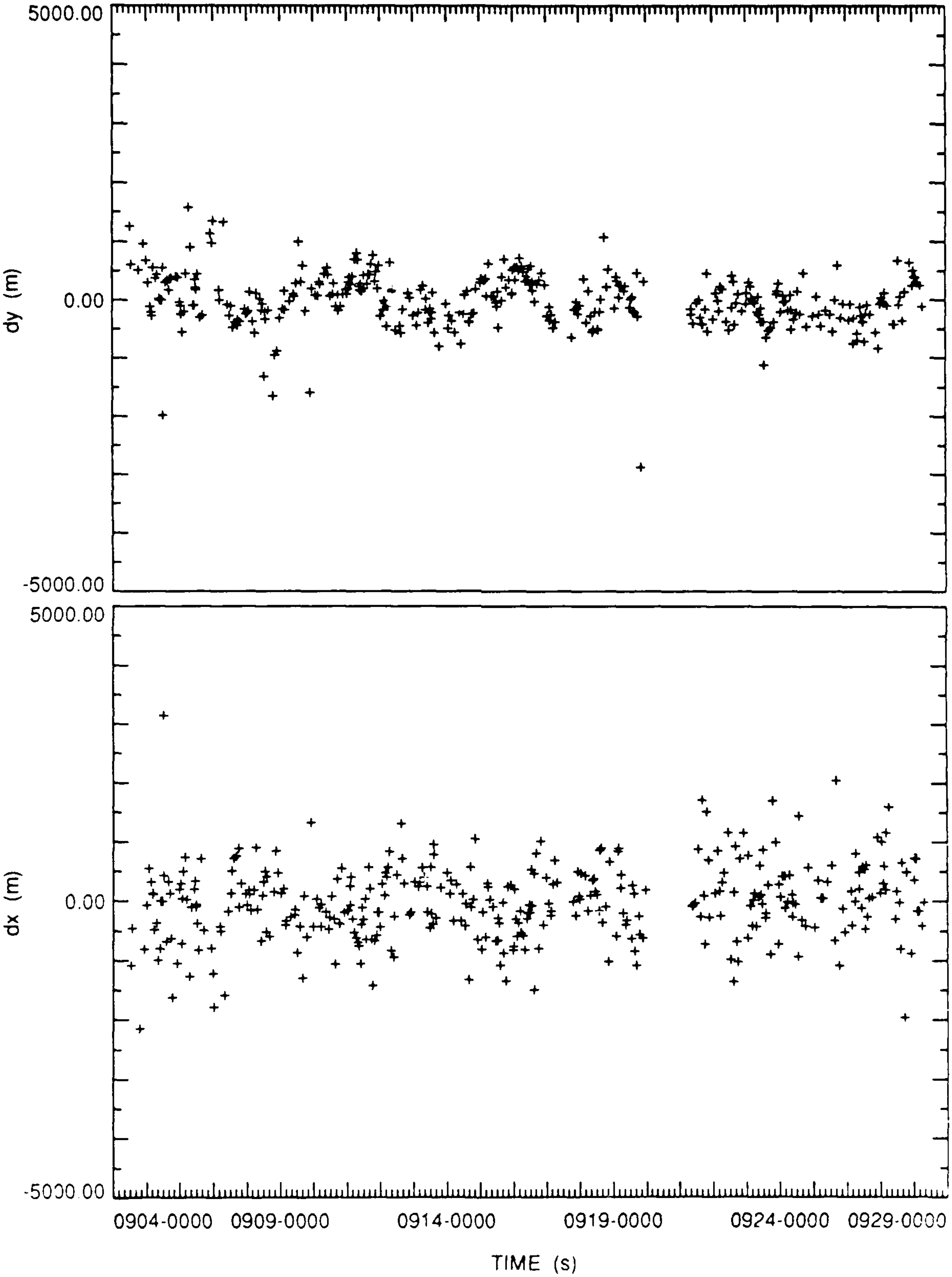

Figure 42. Position difference between transit fixes and Loran-C data.

6. REFERENCES

Ambar, I., and M. R. Howe, 1979a. Observations of the Mediterranean outflow. I. Mixing in the Mediterranean outflow, *Deep-Sea Res.*, *26A*, 535–554.

Ambar, I., and M. R. Howe, 1979b. Observations of the Mediterranean outflow. II. The deep circulation in the vicinity of the Gulf of Cadiz, *Deep-Sea Res.*, *26A*, 555–568.

Armi, L., and W. Zenk, 1984. Large lenses of highly saline Mediterranean water, *J. Phys. Oceanogr.*, *14*, 1560–1576.

Armi, L., D. Herbert, N. Oakey, J. Price, P. L. Richardson, T. Rossby, and B. Ruddick, 1988. Two years in the life of a Mediterranean salt lens (submitted to *J. Phys. Oceanogr.*)

Heinmiller, R. H., C. C. Ebbesmeyer, B. A. Taft, D. B. Olson, and O. P. Nikitin, 1983. Systematic errors in Expendable Bathythermograph (XBT) profiles, *Deep-Sea Res.*, *30*, 1185–1196.

Lewis, E. L., 1980. The practical salinity scale of 1978 and its antecedents, *IEEE J. Ocean. Eng.*, *OE-5*, 3–8.

McDowell, S. E., and H. T. Rossby, 1978. Mediterranean water: an intense mesoscale eddy off the Bahamas, *Science*, *202*, 1085–1087.

Press, W. H., B. P. Flannery, S. A. Teukolsky, and W. T. Vetterling, 1986. *Numerical Recipes*. Cambridge University Press, New York, 818 pp.

Saunders, P. M., and N. P. Fofonoff, 1976. Conversion of pressure to depth in the ocean, *Deep-Sea Res.*, *23*, 109–111.

Serrano, E. S., 1962. Nota acerca de la vena septentrional de aqua de procedencia Mediterranea en el Mar de Cadiz, *Revista de Geofisica*, *84*, 331–358.

APPENDICES

Note: In these appendices, "Method" refers to the navigation method used to obtain the positions listed. LC denotes Loran-C and OM denotes differential Omega. All times are GMT. All latitudes are in degrees, decimal minutes North, and all longitudes are in degrees, decimal minutes West.

APPENDIX A

Oceanus Cruise 202
XCP Log

Drop #	Serial #	Channel #	Date	Time	Latitude	Longitude	Method	Comment
			Ampere Seamount Survey 1					
2401	88031	12	09/08/88	13:59	35 03.89	12 51.00	LC*	good
2402	88142	14	09/08/88	14:06	35 03.94	12 50.61	LC	good
2403	871084	16	09/08/88	14:12	35 03.98	12 50.28	LC	good
2404	88215	12	09/08/88	14:17	35 03.96	12 49.97	LC	good
2405	88159	14	09/08/88	14:19	35 03.97	12 49.84	LC	good
2406	8708290	16	09/08/88	14:25	35 03.98	12 49.52	LC	good
2407	88179	12	09/08/88	14:29	35 03.98	12 49.28	LC	good
2408	88153	14	09/08/88	14:34	35 04.00	12 49.03	LC	good
2409	88206	16	09/08/88	14:38	35 04.00	12 48.79	LC	good
2410	88038	12	09/08/88	14:43	35 04.00	12 48.50	LC	Note 1
2411	88141	14	09/08/88	14:47	35 04.00	12 48.26	LC	good
2412	871079	16	09/08/88	15:20	35 01.98	12 49.15	LC	good
2413	8708209	12	09/08/88	15:24	35 02.12	12 49.18	LC	good
2414	871027	14	09/08/88	15:29	35 02.33	12 49.21	LC	good
2415	8708289	16	09/08/88	15:33	35 02.52	12 49.27	LC	good
2416	88196	12	09/08/88	15:37	35 02.68	12 49.31	LC	good
2417	871047	14	09/08/88	15:41	35 02.84	12 49.34	LC	good
2418	87087	16	09/08/88	15:46	35 03.05	12 49.40	LC	good
2419	871044	12	09/08/88	15:49	35 03.17	12 49.43	LC	T bad
2420	871065	14	09/08/88	15:53	35 03.32	12 49.47	LC	good
2421	88187	16	09/08/88	15:58	35 03.52	12 49.55	LC	good
2422	88184	10	09/08/88	16:05	35 03.85	12 49.65	LC	good
2423	8710126	14	09/08/88	16:10	35 04.07	12 49.72	LC	good
2424	871068	16	09/08/88	16:15	35 04.31	12 49.82	LC	good
2425	88171	10	09/08/88	16:22	35 04.63	12 49.92	LC	good
2426	8710135	14	09/08/88	16:27	35 04.87	12 50.02	LC	good
2427	871093	16	09/08/88	16:35	35 05.25	12 50.15	LC	good
2428	88101	10	09/08/88	16:41	35 05.60	12 50.17	LC	good

*Dead-reckoned position based on LC-derived positions for drops 2 and 3.

Drop #	Serial #	Channel #	Date	Time	Latitude	Longitude	Method	Comment
			Ampere Seamount Survey 2					
2429	88174	10	09/09/88	14:00	35 02.10	12 48.60	LC	good
2430	88150	14	09/09/88	14:05	35 02.05	12 48.03	LC	good
2431	8710100	16	09/09/88	14:10	35 02.00	12 47.52	LC	bad
2432	88153	10	09/09/88	14:12	35 01.98	12 47.40	LC	good
2433	88178	14	09/09/88	14:15	35 01.96	12 47.27	LC	good
2434	8708292	16	09/09/88	14:21	35 01.91	12 46.98	LC	good
2435	88169	10	09/09/88	14:26	35 01.87	12 46.72	LC	good
2436	88207	14	09/09/88	14:31	35 01.80	12 46.42	LC	good
2437	871059	16	09/09/88	14:35	35 01.78	12 46.22	LC	good
2438	88162	10	09/09/88	14:40	35 01.72	12 45.94	LC	good
2439	88194	14	09/09/88	14:45	35 01.67	12 45.66	LC	good
2440	871057	16	09/09/88	14:50	35 01.63	12 45.39	LC	started late
2441	88160	10	09/09/88	14:58	35 01.58	12 44.81	LC	good
2442	88211	14	09/09/88	15:03	35 01.57	12 44.25	LC	good
2443	8710149	16	09/09/88	15:56	34 59.50	12 46.53	LC	T bad
2444	88188	12	09/09/88	16:04	35 00.38	12 46.62	LC	good
2445	88209	14	09/09/88	16:08	35 00.79	12 46.62	LC	good
2446	8710134	16	09/09/88	16:14	35 01.09	12 46.68	LC	bad
2447	88161	10	09/09/88	16:16	35 01.23	12 46.70	LC	good
2448	871089	14	09/09/88	16:24	35 01.72	12 46.79	LC	good
2449	870825	16	09/09/88	16:27	35 01.88	12 46.79	LC	T bad
2450	88177	10	09/09/88	16:30	35 02.05	12 46.83	LC	good
2451	8708286	14	09/09/88	16:35	35 02.30	12 46.79	LC	good
2452	8708281	16	09/09/88	16:40	35 02.56	12 46.77	LC	good
2453	88168	10	09/09/88	16:45	35 02.80	12 46.73	LC	good
2454	88208	16	09/09/88	16:54	35 03.55	12 46.63	LC	good
2455	88189	14	09/09/88	17:00	35 04.20	12 46.59	LC	good

Drop #	Serial #	Channel #	Date	Time	Latitude	Longitude	Method	Comment
			Cape St. Vincent Region					
			(line 2)					
2456	87085	12	09/11/88	09:24	36 47.82	8 13.71	LC	good
2457	88205	12	09/11/88	09:43	36 44.07	8 13.75	LC	Note 1
2458	870842	12	09/11/88	10:00	36 40.70	8 13.86	LC	noisy
2459	88155	10	09/11/88	10:05	36 39.70	8 13.86	LC	good
2460	8708170	12	09/11/88	10:30	36 35.10	8 13.54	LC	good
2461	8708197	12	09/11/88	10:58	36 30.57	8 13.01	LC	Note 2
2462	88039	12	09/11/88	11:32	36 23.88	8 12.43	LC	bad
2463	88169A	10	09/11/88	11:32	36 23.88	8 12.43	LC	good
2464	871064	12	09/11/88	11:51	36 20.08	8 12.48	LC	good
2465	871061	12	09/11/88	12:20	36 15.36	8 12.88	LC	good
			(line 4)					
2466	871058	12	09/11/88	22:40	36 39.40	8 38.37	LC	good
2467	88142	10	09/12/88	00:21	36 34.63	8 37.70	LC	good
2468	88165	10	09/12/88	02:05	36 30.31	8 36.85	LC	good
2469	88175	10	09/12/88	03:50	36 24.95	8 37.34	LC	Note 3
2470	88170A	10	09/12/88	05:38	36 20.27	8 37.80	LC	good
2471	88161A	10	09/12/88	07:48	36 15.30	8 38.02	LC	good
2472	88150	10	09/12/88	09:32	36 10.96	8 38.03	LC	good
2473	88157	10	09/12/88	11:41	36 05.12	8 37.54	LC	good
2474	88163	10	09/12/88	13:33	35 59.61	8 37.64	LC	good
2475	88158	10	09/12/88	15:37	35 54.60	8 37.96	LC	good
			(line 5)					
2476	88176	10	09/12/88	20:07	36 36.07	8 41.75	LC	Note 3
			(line 6)					
2477	8708118	12	09/12/88	23:25	36 34.63	8 50.64	LC	good
2478	871026	12	09/13/88	00:01	36 29.70	8 49.52	LC	good
			(line 7)					
2479	870824	12	09/13/88	06:49	36 29.77	8 55.01	LC	good
2480	88035	16	09/13/88	07:22	36 34.51	8 54.27	LC	bad

Drop #	Serial #	Channel #	Date	Time	Latitude	Longitude	Method	Comment
				(line 8)				
2481	871048	16	09/13/88	11:04	36 39.60	9 02.56	LC	good
2482	871086	14	09/13/88	12:46	36 34.59	9 01.51	LC	good
2483	8710173	16	09/13/88	14:37	36 29.50	9 02.09	LC	good
2484	871088	16	09/13/88	18:36	36 15.05	9 04.17	LC	good
2485	88036	16	09/13/88	20:27	36 09.66	9 02.50	LC	good
				(line 17)				
2486	8710133	16	09/15/88	12:20	37 11.01	9 16.99	LC	good
2487	8708282	16	09/15/88	15:44	37 09.14	9 34.49	LC	good
2488	870819	16	09/15/88	17:34	37 09.25	9 41.09	LC	good
2489	88034	16	09/15/88	20:05	37 10.65	9 48.16	LC	good
				Meddy Survey (leg 1)				
2490	8710122	16	09/17/88	21:07	35 55.05	9 12.79	LC	T bad
2491	871050	14	09/17/88	21:31	35 57.14	9 12.48	LC	Note 4
2492	871073	14	09/17/88	21:52	35 59.00	9 12.16	LC	good
2493	871094	14	09/17/88	22:10	36 00.58	9 11.82	LC	good
2494	88125	14	09/17/88	22:32	36 02.52	9 11.44	LC	good
2495	88166	14	09/17/88	22:50	36 04.11	9 11.09	LC	good
2496	88151A	14	09/17/88	23:08	36 05.69	9 10.77	LC	good
2497	88210	14	09/17/88	23:29	36 07.45	9 10.46	LC	good
2498	88154	14	09/17/88	23:48	36 09.09	9 10.60	LC	good
2499	871049	14	09/18/88	00:08	36 10.75	9 10.97	LC	Note 4
2500	88173	14	09/18/88	00:27	36 12.34	9 11.43	LC	good
				Meddy Survey (leg 2)				
2501	88181	10	09/18/88	02:49	36 08.71	9 05.54	LC	good
2502	88168	10	09/18/88	03:20	36 06.71	9 07.66	LC	good
2503	88170	10	09/18/88	03:40	36 05.75	9 09.74	LC	bad
2504	88145	10	09/18/88	03:42	36 05.66	9 09.99	LC	good
2505	88130	10	09/18/88	04:03	36 04.79	9 12.27	LC	good
2506	88183	10	09/18/88	04:23	36 03.88	9 14.35	LC	good
2507	88163	10	09/18/88	04:44	36 02.93	9 16.56	LC	good
2508	88108	10	09/18/88	05:34	36 01.56	9 18.80	LC	good
2509	88165	10	09/18/88	05:54	36 00.65	9 21.03	LC	good
2510	88157	10	09/18/88	06:16	35 59.73	9 23.46	LC	good

Drop #	Serial #	Channel #	Date	Time	Latitude	Longitude	Method	Comment
Meddy Survey (leg 3)								
2511	870874	12	09/18/88	07:48	36 09.92	9 20.43	LC	good
2512	870884	12	09/18/88	08:08	36 08.82	9 18.53	LC	good
2513	870318	12	09/18/88	08:28	36 07.78	9 16.63	LC	bad
2514	870322	12	09/18/88	08:30	36 07.67	9 16.44	LC	T bad
2515	88180	12	09/18/88	08:50	36 06.61	9 14.63	LC	good
2516	870320	12	09/18/88	09:10	36 05.53	9 12.88	LC	good
2517	870841	12	09/18/88	09:40	36 04.04	9 10.25	LC	good
2518	88212	12	09/18/88	10:06	36 02.85	9 08.05	LC	good
2519	88169	12	09/18/88	10:30	36 01.73	9 06.14	LC	good
2520	870845	12	09/18/88	10:55	36 00.67	9 04.31	LC	good

Drop #	Serial #	Channel #	Date	Time	Latitude	Longitude	Method	Comment
			Outflow Component					
			(site 1)					
2521	8710128	16	09/21/88	13:33	35 48.46	6 12.18	LC	bad
2522	88202	14	09/21/88	13:58	35 49.14	6 12.64	LC	good
			(site 2)					
2523	871096	16	09/21/88	15:45	35 51.40	6 00.96	LC	good
			(site 3)					
2524	871062	16	09/21/88	17:06	35 53.18	5 52.54	LC	bad
2525	88143	10	09/21/88	17:10	35 53.26	5 52.44	LC	good
			(site 1)					
2526	871082	16	09/21/88	19:30	35 48.99	6 13.10	LC	bad
2527	870839	12	09/21/88	19:36	35 49.02	6 12.94	LC	good
			(site 4)					
2528	8710132	16	09/21/88	22:22	35 46.10	6 20.82	LC	good
			(site 5)					
2529	8710101	16	09/22/88	02:10	35 45.39	6 28.57	LC	good
			(site 1)					
2530	870403	16	09/22/88	04:41	35 48.71	6 12.34	LC	good
			(site 4)					
2531	871091	16	09/22/88	05:56	35 46.04	6 20.39	LC	good
			(site 5)					
2532	8708127	16	09/22/88	07:40	35 45.49	6 29.68	LC	good
			(site 6)					
2533	870316	12	09/22/88	09:08	35 49.74	6 37.46	LC	good

Drop #	Serial #	Channel #	Date	Time	Latitude	Longitude	Method	Comment
				(site 7)				
2534	8710148	14	09/22/88	10:36	35 53.82	6 30.43	LC	good
				(site 8)				
2535	8708166	12	09/22/88	12:04	35 54.44	6 24.44	LC	good
				(site 9)				
2536	8708126	12	09/22/88	14:18	35 45.34	6 40.74	LC	good
				Section A				
2537	870846	12	09/22/88	17:34	35 45.68	6 13.47	LC	good
2538	88115	12	09/22/88	18:25	35 49.21	6 13.77	LC	good
2539	88158	14	09/22/88	19:20	35 51.57	6 14.42	LC	good
2540	871028	12	09/22/88	20:16	35 55.14	6 12.53	LC	good
				Section B				
2541	88170	12	09/22/88	22:58	35 48.76	6 19.80	LC	good
2542	871085	14	09/23/88	00:05	35 45.58	6 18.34	LC	good
2543	88195	14	09/23/88	00:56	35 42.62	6 17.59	LC	good
				Section C				
2544	870823	12	09/23/88	04:45	35 45.04	6 29.51	LC	good
2545	870331	12	09/23/88	05:55	35 46.49	6 29.28	LC	good
2546	8708125	12	09/23/88	06:55	35 49.51	6 27.00	LC	good
2547	8710129	14	09/23/88	08:12	35 51.04	6 27.35	LC	good
2548	88156	10	09/23/88	09:18	35 54.59	6 27.22	LC	good
				Section D				
2549	88148	10	09/23/88	11:50	35 55.65	6 28.43	LC	good
2550	88152	14	09/23/88	12:45	35 53.47	6 29.27	LC	good
2551	88122	10	09/23/88	13:39	35 51.72	6 32.25	LC	good
2552	88175	14	09/23/88	14:31	35 50.22	6 34.89	LC	good
2553	871045	14	09/23/88	15:56	35 48.67	6 37.25	LC	good
2554	88191	12	09/23/88	17:07	35 46.65	6 39.67	LC	good
2555	88144	10	09/23/88	18:11	35 43.45	6 41.76	LC	good

Drop #	Serial #	Channel #	Date	Time	Latitude	Longitude	Method	Comment
(Station C4)								
2556	88146	10	09/23/88	22:29	35 44.64	6 29.83	LC	good
Section E								
2557	8708280	14	09/24/88	01:43	36 01.24	6 33.09	LC	good
2558	88160	14	09/24/88	02:57	36 00.41	6 37.19	LC	good
2559	8708293	14	09/24/88	04:06	35 59.33	6 40.43	LC	good
2560	88159	10	09/24/88	05:14	35 57.60	6 43.59	LC	questionable
2561	88216	16	09/24/88	05:21	35 57.53	6 43.86	LC	fair
2562	88032	16	09/24/88	06:32	35 55.77	6 46.26	LC	good
2563	88193	16	09/24/88	07:47	35 54.53	6 48.71	LC	good
Section F								
2564	871081	14	09/24/88	18:01	36 18.66	6 44.25	LC	good
2565	88173	10	09/24/88	18:56	36 17.78	6 46.68	LC	good
2566	88167	10	09/24/88	20:03	36 16.15	6 49.13	LC	good
2567	88141	10	09/24/88	21:03	36 14.66	6 52.38	LC	good
2568	88143A	10	09/24/88	21:55	36 12.46	6 54.77	LC	Note 2
2569	88167	10	09/24/88	23:23	36 10.88	6 57.91	LC	good
2570	88118	12	09/25/88	01:08	36 09.11	7 01.68	LC	good
2571	870872	12	09/25/88	03:25	36 06.42	7 07.74	LC	good
Section FE								
2572	871041	16	09/26/88	21:45	35 54.63	7 05.19	LC	good
(Station C4)								
2573	871095	16	09/27/88	02:09	35 45.85	6 29.08	LC	good
Section I								
2574	871037	12	09/27/88	10:24	35 59.17	5 23.50	LC	good
2575	871074	14	09/27/88	12:46	35 56.25	5 35.68	LC	good
2576	871099	14	09/27/88	14:29	35 55.38	5 45.16	LC	fair
2577	88204	16	09/27/88	17:24	35 51.21	5 59.46	LC	good
2578	871060	16	09/27/88	19:56	35 49.11	6 11.34	LC	Note 1
(Station B8)								
2579	871080	16	09/27/88	20:59	35 48.82	6 20.37	LC	good

Drop #	Serial #	Channel #	Date	Time	Latitude	Longitude	Method	Comment
				(Station C4)				
2580	871067	16	09/27/88	21:50	35 45.28	6 29.19	LC	good
				(Station D6)				
2581	8710136	16	09/27/88	22:38	35 51.50	6 34.95	LC	good
				(Extra station)				
2582	870317	12	09/27/88	23:22	35 53.18	6 44.10	LC	good
				(Station E6)				
2583	88197	14	09/27/88	23:56	35 54.35	6 50.43	LC	good
				(Extra station)				
2584	88149	10	09/28/88	00:47	36 01.12	6 45.91	LC	good

Note 1. Electrodes reversed.
Note 2. Needs to be played back.
Note 3. Wire broke early.
Note 4. 1/2 compass coil area.

APPENDIX B

Oceanus Cruise 202
XBT Log

Drop #	Serial #	Type	Date	Time	Latitude	Longitude	Method	Comment
				Test drops				
1		T-6	09/04/88	17:52	33 07.92	16 01.20	LC	good
2		T-6	09/04/88	17:58	33 07.96	16 01.37	LC	good
				Ampere Seamount Survey				
3		T-7	09/05/88	19:00	35 15.18	12 36.79	LC	good
4		T-7	09/05/88	19:30	35 19.28	12 34.94	LC	good
5		T-7	09/05/88	20:00	35 19.44	12 42.45	LC	good
6		T-7	09/05/88	20:27	35 19.62	12 48.79	LC	good
7		T-7	09/05/88	20:58	35 20.06	12 56.17	LC	good
8		T-7	09/05/88	21:28	35 20.29	13 03.28	LC	good
9		T-7	09/05/88	22:02	35 20.17	13 10.86	LC	good
10		T-7	09/05/88	22:30	35 15.33	13 11.41	LC	good
11		T-7	09/05/88	22:59	35 10.42	13 12.32	LC	good
12		T-7	09/05/88	23:29	35 04.98	13 13.05	LC	good
13		T-7	09/06/88	00:00	34 58.87	13 12.91	LC	good
14		T-7	09/06/88	00:29	34 53.40	13 11.90	LC	good
15		T-7	09/06/88	01:04	34 47.66	13 10.66	OM	good
16		T-7	09/06/88	01:31	34 47.17	13 04.28	LC	good
17		T-7	09/06/88	01:59	34 46.15	12 56.96	LC	good
18		T-7	09/06/88	02:29	34 46.55	12 50.25	LC	good
19		T-7	09/06/88	03:00	34 46.53	12 43.22	LC	good
20		T-7	09/06/88	03:30	34 46.57	12 36.54	LC	good
21		T-7	09/06/88	03:59	34 48.85	12 32.98	LC	bad below 350m
22		T-7	09/06/88	04:10	34 50.91	12 32.94	LC	good
23		T-7	09/06/88	04:29	34 54.42	12 32.68	LC	good
24		T-7	09/06/88	05:00	35 00.18	12 32.32	LC	good
25		T-7	09/06/88	05:30	35 05.32	12 31.76	LC	good
26		T-7	09/06/88	06:00	35 11.40	12 32.60	LC	good
27		T-7	09/06/88	06:30	35 17.30	12 33.10	LC	good
				Cape St. Vincent Region				
				(line 1)				
28		T-5	09/11/88	02:30	36 00.46	8 00.22	LC	hit bottom 1460m
29		T-5	09/11/88	03:00	36 05.33	8 00.74	LC	good
30		T-5	09/11/88	03:30	36 09.99	8 00.69	LC	bad below 175m
31		T-5	09/11/88	03:36	36 10.55	8 00.74	LC	hit bottom 1440m

Drop #	Serial #	Type	Date	Time	Latitude	Longitude	Method	Comment
32		T-5	09/11/88	03:59	36 14.14	8 00.75	LC	hit bottom 1350m
33		T-5	09/11/88	04:29	36 19.06	8 00.80	LC	hit bottom 1250m
34		T-5	09/11/88	05:02	36 24.26	8 00.54	LC	hit bottom 1150m
35		T-5	09/11/88	05:29	36 28.49	8 00.17	LC	hit bottom 795m
36		T-5	09/11/88	05:59	36 33.72	7 59.94	LC	hit bottom 775m
37		T-7	09/11/88	06:29	36 39.02	7 59.86	LC	good
38		T-7	09/11/88	06:59	36 44.33	7 59.98	LC	hit bottom 700m
39		T-6	09/11/88	07:29	36 49.58	8 00.10	LC	hit bottom 400m
40		T-6	09/11/88	07:59	36 55.39	8 00.96	LC	hit bottom 80m
				(line 2)				
41		T-6	09/11/88	08:46	36 55.80	8 13.01	LC	hit bottom at 50m
42		T-7	09/11/88	09:53	36 42.08	8 13.85	LC	hit bottom at 690m
43		T-5	09/11/88	10:17	36 37.25	8 13.79	LC	hit bottom at 840m
44		T-5	09/11/88	10:42	36 33.00	8 13.26	LC	hit bottom at 1110m
45		T-5	09/11/88	11:11	36 28.00	8 12.68	LC	needs playback
46		T-5	09/11/88	11:29	36 24.47	8 12.38	LC	hit bottom 1150m
47		T-5	09/11/88	12:03	36 17.97	8 12.62	LC	good
48		T-5	09/11/88	12:41	36 11.19	8 13.44	LC	wire broke 1125m
49		T-5	09/11/88	12:47	36 10.02	8 13.47	LC	wire broke 1125m
50		T-5	09/11/88	13:05	36 06.63	8 12.69	LC	noisy
51		T-5	09/11/88	13:11	36 06.11	8 12.58	LC	good
52		T-5	09/11/88	13:30	36 03.02	8 12.74	LC	? below 1100m
				(line 3)				
53		T-5	09/11/88	14:29	36 00.20	8 25.09	LC	no file created
54		T-5	09/11/88	14:33	36 00.61	8 25.08	LC	bad
55		T-5	09/11/88	15:04	36 05.87	8 24.89	LC	needs playback
56		T-5	09/11/88	15:35	36 11.05	8 24.73	LC	bad
57		T-5	09/11/88	15:42	36 11.72	8 24.74	LC	bad
58		T-5	09/11/88	16:17	36 16.47	8 24.62	LC	hit bottom 1590m
59		T-5	09/11/88	16:52	36 21.94	8 24.35	LC	bad
60		T-7	09/11/88	16:59	36 22.68	8 24.28	LC	good
61		T-5	09/11/88	17:24	36 27.20	8 24.02	LC	hit bottom 1440m
62		T-5	09/11/88	18:00	36 34.06	8 23.71	LC	hit bottom 1300m
63		T-7	09/11/88	18:34	36 40.42	8 24.19	LC	hit bottom at 730m
64		T-7	09/11/88	18:58	36 44.53	8 25.66	LC	good
65		T-6	09/11/88	19:20	36 48.36	8 26.41	LC	hit bottom at 310m

Drop #	Serial #	Type	Date	Time	Latitude	Longitude	Method	Comment
					(line 4)			
66		T-6	09/11/88	20:13	36 50.32	8 36.96	LC	hit bottom at 250m
67		T-5	09/12/88	11:32	36 05.78	8 37.61	LC	bad
68		T-5	09/12/88	11:35	36 05.57	8 37.62	LC	bad below 300m
69		T-5	09/12/88	13:30	35 59.86	8 37.57	LC	good
70		T-5	09/12/88	15:35	35 54.57	8 37.69	LC	good
					(line 5)			
71		T-5	09/12/88	16:02	35 55.07	8 42.29	LC	good
72		T-5	09/12/88	16:36	36 00.51	8 41.49	LC	good
73		T-5	09/12/88	17:04	36 05.35	8 41.25	LC	good
74		T-5	09/12/88	17:31	36 10.13	8 41.51	LC	good
75		T-5	09/12/88	18:03	36 16.10	8 41.96	LC	good
76		T-5	09/12/88	18:31	36 21.07	8 42.05	LC	good
77		T-5	09/12/88	18:56	36 25.33	8 42.01	LC	T jump at 250m
78		T-5	09/12/88	19:27	36 30.46	8 41.72	LC	hit bottom 1290m
79		T-5	09/12/88	19:32	36 30.93	8 41.67	LC	hit bottom 1260m
80		T-5	09/12/88	20:00	36 35.20	8 41.72	LC	hit bottom 1020m
81		T-7	09/12/88	20:26	36 39.73	8 42.51	LC	bad below 470m
82		T-7	09/12/88	21:06	36 45.58	8 44.22	LC	hit bottom 650m
					(line 6)			
83		T-7	09/12/88	22:17	36 45.04	8 50.58	LC	bad
84		T-7	09/12/88	22:19	36 44.82	8 50.66	LC	hit bottom 650m
85		T-5	09/12/88	22:49	36 40.50	8 51.08	LC	hit bottom 740m
86		T-5	09/12/88	23:25	36 34.63	8 50.64	LC	hit bottom 1200m
87		T-5	09/12/88	23:52	36 30.55	8 49.79	LC	bad
88		T-5	09/12/88	23:56	36 30.20	8 49.70	LC	good
89		T-5	09/13/88	00:24	36 25.79	8 48.86	LC	good
90		T-5	09/13/88	01:02	36 20.07	8 48.04	LC	good
91		T-5	09/13/88	01:33	36 14.90	8 48.95	LC	good
92		T-5	09/13/88	02:06	36 09.60	8 49.85	LC	good
93		T-5	09/13/88	02:38	36 04.44	8 50.42	LC	good
94		T-5	09/13/88	03:08	35 59.56	8 49.74	LC	good

Drop #	Serial #	Type	Date	Time	Latitude	Longitude	Method	Comment
				(line 7)				
95		T-5	09/13/88	03:43	36 00.11	8 55.78	LC	good
96		T-5	09/13/88	04:13	36 04.89	8 55.76	LC	good
97		T-5	09/13/88	04:43	36 09.65	8 55.84	LC	good
98		T-5	09/13/88	05:15	36 14.86	8 55.96	LC	good
99		T-5	09/13/88	05:45	36 19.77	8 55.89	LC	good
100		T-5	09/13/88	06:17	36 25.02	8 55.62	LC	good
101		T-5	09/13/88	06:47	36 29.61	8 55.07	LC	good
102		T-5	09/13/88	07:18	36 34.21	8 54.37	LC	needs playback
103		T-5	09/13/88	08:12	36 39.64	8 54.79	LC	hit bottom at 750m
104		T-7	09/13/88	08:42	36 45.03	8 55.97	LC	hit bottom at 675m
				(line 8)				
105		T-5	09/13/88	12:54	36 33.78	9 01.30	LC	bad below 1500m
106	178742	T-5	09/13/88	16:17	36 24.64	9 02.51	LC	good
107	200982	T-5	09/13/88	16:53	36 19.81	9 02.93	LC	good
108	200981	T-5	09/13/88	21:03	36 02.81	9 01.14	LC	good
				(lines 9 thru 12)				
109	200980	T-5	09/13/88	23:25	35 59.96	9 08.69	LC	good
110	200985	T-5	09/14/88	00:24	36 09.87	9 09.23	LC	good
111	200984	T-5	09/14/88	00:59	36 09.91	9 16.73	LC	good
112	200983	T-5	09/14/88	01:29	36 10.28	9 23.24	LC	good
113	200986	T-5	09/14/88	02:00	36 10.66	9 29.86	LC	good
114	200988	T-5	09/14/88	02:29	36 10.13	9 36.05	LC	good
115	200987	T-5	09/14/88	02:53	36 09.92	9 40.31	LC	good
116	200846	T-5	09/14/88	03:38	36 14.97	9 45.59	LC	good
117	200847	T-5	09/14/88	04:24	36 20.51	9 51.53	LC	good
118	200845	T-5	09/14/88	04:56	36 20.22	9 44.81	LC	good
119	200848	T-5	09/14/88	05:30	36 19.91	9 37.69	LC	good
120	200843	T-5	09/14/88	05:59	36 19.61	9 31.71	LC	good
121	200850	T-5	09/14/88	06:29	36 19.29	9 25.42	LC	good
122	200859	T-5	09/14/88	06:59	36 18.69	9 19.08	LC	good
123	200842	T-5	09/14/88	07:29	36 19.28	9 13.07	LC	good
124	200851	T-5	09/14/88	08:00	36 21.06	9 08.07	LC	good

Drop #	Serial #	Type	Date	Time	Latitude	Longitude	Method	Comment
					(line 13)			
125	200854	T-5	09/14/88	09:06	36 31.05	9 08.63	LC	good
126	200855	T-5	09/14/88	09:45	36 30.83	9 14.82	LC	bad below 1600m
127	200856	T-5	09/14/88	10:15	36 30.65	9 20.34	LC	good
128	200889	T-5	09/14/88	10:23	36 30.58	9 21.23	LC	T offset
129	200890	T-5	09/14/88	10:51	36 30.46	9 26.68	LC	good
130	200891	T-5	09/14/88	11:21	36 30.38	9 32.69	LC	good
131	200892	T-5	09/14/88	11:56	36 30.26	9 39.61	LC	good
132	200881	T-5	09/14/88	12:33	36 30.22	9 47.16	LC	good
133	200882	T-5	09/14/88	13:00	36 30.35	9 52.31	LC	good
134	200883	T-5	09/14/88	13:31	36 30.47	9 58.33	LC	good
135	200884	T-5	09/14/88	14:02	36 30.48	10 04.45	LC	good
136	200885	T-5	09/14/88	14:38	36 30.71	10 10.84	LC	good
					(line 14)			
137	200886	T-5	09/14/88	15:43	36 40.78	10 09.73	LC	good
138	200887	T-5	09/14/88	16:02	36 40.55	10 05.98	LC	good
139	200888	T-5	09/14/88	16:30	36 40.37	10 00.31	LC	good
140	200913	T-5	09/14/88	16:58	36 39.46	9 54.49	LC	good
141		T-5	09/14/88	17:44	36 39.16	9 44.49	LC	bad
142	200914	T-5	09/14/88	17:45	36 39.16	9 44.38	LC	T offset
143	200915	T-5	09/14/88	18:21	36 39.51	9 38.90	LC	good
144	200916	T-5	09/14/88	18:47	36 39.26	9 33.09	LC	good
145	200905	T-5	09/14/88	19:18	36 39.03	9 26.71	LC	good
146	200912	T-5	09/14/88	19:47	36 38.66	9 20.40	LC	hit botoom 1500m
147	200911	T-5	09/14/88	20:19	36 38.27	9 14.89	LC	hit botoom 1600m
148	200910	T-5	09/14/88	21:01	36 40.31	9 06.74	LC	hit bottom 1000m
					(line 15)			
149	200906	T-5	09/14/88	22:01	36 49.92	9 07.97	LC	hit bottom 600m
150	640596	T-7	09/14/88	22:42	36 49.29	9 16.43	LC	bad
151	640591	T-7	09/14/88	22:46	36 49.25	9 16.91	LC	good
152	200907	T-5	09/14/88	23:16	36 49.16	9 22.99	LC	hit bottom 850m
153	200908	T-5	09/14/88	23:43	36 49.31	9 28.51	LC	hit bottom 1275m
154	200909	T-5	09/15/88	00:15	36 49.80	9 34.87	LC	good
155	200413	T-5	09/15/88	00:50	36 50.33	9 41.65	LC	good
156	200414	T-5	09/15/88	01:19	36 50.77	9 47.27	LC	good
157	200415	T-5	09/15/88	01:49	36 50.91	9 53.37	LC	good

Drop #	Serial #	Type	Date	Time	Latitude	Longitude	Method	Comment
				(line 15), cont.				
158	200416	T-5	09/15/88	02:23	36 50.73	10 00.08	LC	good
159	200417	T-5	09/15/88	02:49	36 50.50	10 05.15	LC	good
160	200418	T-5	09/15/88	03:22	36 50.61	10 11.18	LC	good
				(line 16)				
161	200419	T-5	09/15/88	04:23	37 00.42	10 11.22	LC	good
162	200420	T-5	09/15/88	04:50	37 00.30	10 06.13	LC	good
163	200421	T-5	09/15/88	05:17	37 00.34	10 00.91	LC	good
164	200422	T-5	09/15/88	06:00	37 00.38	9 52.16	LC	bad below 150m
165	200423	T-5	09/15/88	06:04	37 00.37	9 51.65	LC	good
166	200424	T-5	09/15/88	06:32	37 00.21	9 45.89	LC	T offset
167	200857	T-5	09/15/88	06:59	37 00.02	9 40.36	LC	good
168	200858	T-5	09/15/88	07:29	36 59.85	9 33.92	LC	hit bottom 1525m
169	200859	T-5	09/15/88	08:01	36 59.83	9 26.78	LC	hit bottom 1525m
170	200860	T-5	09/15/88	08:29	36 59.77	9 20.41	LC	good
171	200861	T-5	09/15/88	09:03	36 59.63	9 13.96	LC	hit bottom 1000m
172	640590	T-7	09/15/88	09:27	37 00.17	9 09.19	LC	hit bottom 600m
				(line 17)				
173	200863	T-5	09/15/88	13:53	37 10.37	9 27.17	LC	hit bottom 1270m
174	200862	T-5	09/15/88	21:22	37 14.42	9 51.45	LC	hit bottom 1550m
				(line 18)				
175	200864	T-5	09/16/88	10:17	37 13.68	10 27.94	LC	good
176	200866	T-5	09/16/88	10:50	37 18.56	10 25.32	LC	good
177	200868	T-5	09/16/88	11:22	37 22.97	10 22.92	LC	good
178	200867	T-5	09/16/88	11:51	37 26.99	10 20.75	LC	good
179	200865	T-5	09/16/88	12:23	37 31.71	10 18.87	LC	bad below 1250m
180	200869	T-5	09/16/88	12:55	37 36.85	10 17.43	LC	bad below 1350m
181	200871	T-5	09/16/88	13:16	37 40.29	10 16.69	LC	good
182	200872	T-5	09/16/88	13:53	37 46.15	10 14.99	LC	bad
183	200873	T-5	09/16/88	13:57	37 46.51	10 14.91	LC	bad

Drop #	Serial #	Type	Date	Time	Latitude	Longitude	Method	Comment
				(line 19)				
184	640592	T-7	09/16/88	21:19	37 51.68	9 29.11	LC	good
				To Meddy and initial search				
185	200876	T-5	09/17/88	04:13	36 39.84	9 19.84	LC	bad below 1300m
186	178744	T-5	09/17/88	05:08	36 30.37	9 18.31	LC	good
187	200875	T-5	09/17/88	06:03	36 20.93	9 14.81	LC	good
188	200877	T-5	09/17/88	06:39	36 16.04	9 11.03	LC	good
189	200878	T-5	09/17/88	07:09	36 12.77	9 06.71	LC	good
190	200879	T-5	09/17/88	07:41	36 09.29	9 02.14	LC	good
191	200880	T-5	09/17/88	08:09	36 09.70	9 06.71	LC	good
192	200893	T-5	09/17/88	08:42	36 10.62	9 13.20	LC	good
193	200894	T-5	09/17/88	09:25	36 05.29	9 13.82	LC	good
194	200895	T-5	09/17/88	09:57	36 00.54	9 14.72	LC	good
195	200896	T-5	09/17/88	10:34	36 00.09	9 09.21	LC	good
196	200897	T-5	09/17/88	11:15	35 59.51	9 02.02	LC	good
197	200901	T-5	09/17/88	11:56	36 04.59	9 01.86	LC	good
198	200902	T-5	09/17/88	12:37	36 05.58	9 08.82	LC	good
199	200903	T-5	09/17/88	13:35	36 04.53	9 20.42	LC	good
200	200898	T-5	09/17/88	16:59	36 04.37	9 10.70	LC	good
				Meddy Survey (leg 1)				
201	200904	T-5	09/17/88	21:33	35 57.30	9 12.46	LC	good
202	200900	T-5	09/17/88	21:52	35 59.00	9 12.16	LC	good
203	200899	T-5	09/17/88	22:11	36 00.68	9 11.79	LC	good
204	201003	T-5	09/17/88	22:32	36 02.52	9 11.44	LC	good
205	201002	T-5	09/17/88	22:52	36 04.26	9 11.04	LC	bad
206	201009	T-5	09/17/88	23:10	36 05.85	9 10.75	LC	good
207	201006	T-5	09/17/88	23:31	36 07.60	9 10.42	LC	bad
208	201005	T-5	09/17/88	23:49	36 09.18	9 10.63	LC	good
209	201001	T-5	09/18/88	00:10	36 10.93	9 11.01	LC	bad
210	201004	T-5	09/18/88	00:30	36 12.58	9 11.52	LC	good

Drop #	Serial #	Type	Date	Time	Latitude	Longitude	Method	Comment
				Meddy Survey (leg 2)				
211	201007	T-5	09/18/88	02:52	36 08.61	9 05.86	LC	good
212	201008	T-5	09/18/88	03:22	36 06.61	9 07.86	LC	good
213	201010	T-5	09/18/88	03:44	36 05.59	9 10.23	LC	good
214	201011	T-5	09/18/88	04:04	36 04.71	9 12.34	LC	bad
215	201012	T-5	09/18/88	04:08	36 04.53	9 12.75	LC	bad
216	200821	T-5	09/18/88	04:25	36 03.81	9 14.57	LC	good
217	178745	T-5	09/18/88	04:46	36 02.83	9 16.76	LC	good
218	200823	T-5	09/18/88	05:35	36 01.54	9 18.91	LC	good
219	200824	T-5	09/18/88	05:56	36 00.58	9 21.24	LC	good
220	200825	T-5	09/18/88	06:18	35 59.63	9 23.68	LC	noisy
				Meddy Survey (leg 3)				
221	200826	T-5	09/18/88	07:50	36 09.80	9 20.24	LC	good
222	200827	T-5	09/18/88	08:09	36 08.77	9 18.45	LC	good
223	200828	T-5	09/18/88	08:32	36 07.57	9 16.25	LC	good
224	200829	T-5	09/18/88	08:53	36 06.44	9 14.35	LC	good
225	200830	T-5	09/18/88	09:12	36 05.42	9 12.71	LC	good
226	200831	T-5	09/18/88	09:43	36 03.90	9 09.97	LC	bad below 300m
227	200832	T-5	09/18/88	10:08	36 02.74	9 07.88	LC	bad below 400m
228	201013	T-5	09/18/88	10:31	36 01.69	9 06.06	LC	good
229	201014	T-5	09/18/88	10:57	36 00.58	9 04.16	LC	good

APPENDIX C

Oceanus Cruise 202
XSV Log

Drop #	Serial #	Type	Date	Time	Latitude	Longitude	Method	Comment
				Cape St. Vincent Region				
				(line 2)				
1		XSV-02	09/11/88	10:42	36 33.00	8 13.26	LC	failed
2		XSV-02	09/11/88	11:11	36 28.00	8 12.68	LC	failed
3		XSV-02	09/11/88	11:29	36 24.47	8 12.38	LC	failed
				(line 3)				
4		XSV-02	09/11/88	15:35	36 11.05	8 24.73	LC	failed
5		XSV-02	09/11/88	16:17	36 16.47	8 24.62	LC	good
6		XSV-02	09/11/88	16:52	36 21.94	8 24.35	LC	failed
7		XSV-02	09/11/88	18:00	36 34.06	8 23.71	LC	failed
				(line 4)				
8		XSV-03	09/11/88	21:14	36 45.45	8 37.47	LC	good
9		XSV-03	09/11/88	22:40	36 39.40	8 38.37	LC	good
				(line 8)				
10		XSV-02	09/13/88	12:54	36 33.78	9 01.30	LC	failed
11		XSV-02	09/13/88	12:55	36 33.68	9 01.29	LC	good
12		XSV-02	09/13/88	16:16	36 24.76	9 02.53	LC	Note 1, good
13		XSV-02	09/13/88	16:53	36 19.81	9 02.93	LC	good
14	013619	XSV-02	09/13/88	21:03	36 02.81	9 01.14	LC	good
				(line 13)				
15	013629	XSV-02	09/14/88	09:16	36 30.98	9 09.70	LC	good
				(line 14)				
16	013626	XSV-02	09/14/88	21:01	36 40.31	9 06.74	LC	good
				(line 15)				
17	013666	XSV-02	09/15/88	00:50	36 50.33	9 41.65	LC	good

Drop #	Serial #	Type	Date	Time	Latitude	Longitude	Method	Comment
				(line 17)				
18	01362	XSV-02	09/15/88	21:22	37 14.42	9 51.45	LC	good
				(line 19)				
19	011177	XSV-03	09/16/88	21:19	37 51.68	9 29.11	LC	good
				To Meddy and initial survey				
20	013630	XSV-02	09/17/88	09:25	36 05.29	9 13.82	LC	Note 1, good
21	013628	XSV-02	09/17/88	09:57	36 00.54	9 14.72	LC	Note 1, good
22	013622	XSV-02	09/17/88	10:34	36 00.09	9 09.21	LC	Note 1, good
23	013627	XSV-02	09/17/88	11:15	35 59.51	9 02.02	LC	good
24	013665	XSV-02	09/17/88	11:56	36 04.59	9 01.86	LC	good
25	013623	XSV-02	09/17/88	12:37	36 05.58	9 08.82	LC	good
26	013624	XSV-02	09/17/88	13:35	36 04.53	9 20.42	LC	good
27	013664	XSV-02	09/17/88	16:59	36 04.37	9 10.70	LC	Notes 1 & 3
				Meddy Survey (leg 1)				
28	013654	XSV-02	09/17/88	21:33	35 57.30	9 12.46	LC	good
29	013643	XSV-02	09/17/88	21:52	35 59.00	9 12.16	LC	good
30	013644	XSV-02	09/17/88	22:11	36 00.68	9 11.79	LC	good
31	013651	XSV-02	09/17/88	22:32	36 02.52	9 11.44	LC	good
32	013653	XSV-02	09/17/88	22:52	36 04.26	9 11.04	LC	failed
33	013652	XSV-02	09/17/88	23:10	36 05.85	9 10.75	LC	good
34	013646	XSV-02	09/17/88	23:31	36 07.60	9 10.42	LC	good
35	013647	XSV-02	09/17/88	23:49	36 09.18	9 10.63	LC	Note 2, good
36	013645	XSV-02	09/18/88	00:10	36 10.93	9 11.01	LC	good
37	013648	XSV-02	09/18/88	00:30	36 12.58	9 11.52	LC	Note 1, good
				Meddy Survey (leg 2)				
38	013649	XSV-02	09/18/88	02:52	36 08.61	9 05.86	LC	Note 1, good
39	013650	XSV-02	09/18/88	03:22	36 06.61	9 07.86	LC	noisy
40	013640	XSV-02	09/18/88	03:44	36 05.59	9 10.23	LC	Note 1, good
41	013641	XSV-02	09/18/88	04:04	36 04.71	9 12.34	LC	good
42	013642	XSV-02	09/18/88	04:25	36 03.81	9 14.57	LC	good
43	013637	XSV-02	09/18/88	04:46	36 02.83	9 16.76	LC	Notes 1 & 4
44	013638	XSV-02	09/18/88	05:35	36 01.54	9 18.91	LC	good
45	013639	XSV-02	09/18/88	05:56	36 00.58	9 21.24	LC	Note 1, good
46	013636	XSV-02	09/18/88	06:18	35 59.63	9 23.68	LC	good

Drop #	Serial #	Type	Date	Time	Latitude	Longitude	Method	Comment
				Meddy Survey (leg 3)				
47	013635	XSV-02	09/18/88	07:50	36 09.80	9 20.24	LC	Note 1, good
48	013634	XSV-02	09/18/88	08:09	36 08.77	9 18.45	LC	Note 1, good
49	013633	XSV-02	09/18/88	08:32	36 07.57	9 16.25	LC	Note 1, good
50	013632	XSV-02	09/18/88	08:53	36 06.44	9 14.35	LC	Note 1, good
51	013631	XSV-02	09/18/88	09:12	36 05.42	9 12.71	LC	good
52	013678	XSV-02	09/18/88	09:43	36 03.90	9 09.97	LC	good
53	013677	XSV-02	09/18/88	10:08	36 02.74	9 07.88	LC	good
54	013676	XSV-02	09/18/88	10:31	36 01.69	9 06.06	LC	good
55	013673	XSV-02	09/18/88	10:57	36 00.58	9 04.16	LC	good

Note 1. Probe end misaligned/rotated to proper alignment.
Note 2. Wire wrapped around tab.
Note 3. Bad below 175 m and 750 m.
Note 4. Bad below 125 m and 175 m.

APPENDIX D

Oceanus Cruise 202
CTD Log

Drop #	Date	Time	Latitude	Longitude	Method	Cast Depth (m)
			Test Cast			
1	09/04/88	16:18	33 08.27	15 59.87	LC	2466
			Ampere Seamount			
2	09/05/88	16:29	35 03.10	12 47.80	LC	1604
3	09/08/88	18:21	35 03.88	12 49.58	LC	1494
4	09/09/88	17:11	35 05.03	12 46.46	LC	1602
5	09/09/88	20:15	35 02.82	12 49.28	LC	1624
6	09/09/88	21:54	35 00.72	12 45.99	LC	1596
7	09/09/88	23:12	35 02.54	12 45.34	LC	1606
			Cape St. Vincent Region			
			(line 4)			
8	09/11/88	20:40	36 45.92	8 37.15	LC	682
9	09/11/88	21:49	36 39.99	8 37.82	LC	758
10	09/11/88	23:15	36 35.09	8 38.17	LC	1308
11	09/12/88	00:49	36 30.23	8 37.39	LC	1992
12	09/12/88	02:37	36 24.86	8 36.97	LC	2022
13	09/12/88	04:25	36 20.19	8 37.44	LC	2006
14	09/12/88	06:14	36 14.99	8 37.46	LC	2000
15	09/12/88	08:22	36 10.51	8 37.93	LC	2002
16	09/12/88	10:12	36 05.29	8 38.15	LC	1988
17	09/12/88	12:24	35 59.97	8 37.48	LC	2020
18	09/12/88	14:14	35 54.37	8 37.53	LC	2018
			(line 8)			
19	09/13/88	09:14	36 45.44	9 01.79	LC	584
20	09/13/88	10:19	36 40.19	9 02.43	LC	780
21	09/13/88	11:22	36 35.83	9 02.07	LC	2002
22	09/13/88	13:21	36 30.13	9 01.96	LC	1988
23	09/13/88	15:02	36 25.22	9 02.05	LC	1992
24	09/13/88	17:29	36 15.13	9 03.52	LC	1992
25	09/13/88	19:06	36 10.15	9 02.10	LC	1996
26	09/13/88	21:31	35 58.61	9 01.23	LC	1970

Drop #	Date	Time	Latitude	Longitude	Method	Cast Depth (m)
			(line 17)			
27	09/15/88	10:33	37 10.39	9 09.37	LC	586
28	09/15/88	11:40	37 10.72	9 15.42	LC	646
29	09/15/88	12:44	37 10.53	9 21.09	LC	884
30	09/15/88	14:36	37 09.83	9 34.59	LC	1750
31	09/15/88	16:17	37 08.90	9 40.19	LC	2014
32	09/15/88	18:06	37 10.36	9 46.58	LC	2012
33	09/15/88	22:35	37 10.14	9 51.95	LC	2004
34	09/16/88	01:17	37 10.59	9 58.67	LC	2014
35	09/16/88	03:01	37 10.57	10 05.61	LC	2006
36	09/16/88	04:45	37 10.79	10 11.69	LC	2016
37	09/16/88	06:22	37 10.76	10 17.19	LC	2024
38	09/16/88	08:32	37 10.38	10 29.00	LC	2002
			(line 19)			
39	09/16/88	14:21	37 49.39	10 14.18	LC	2014
40	09/16/88	17:56	37 49.00	9 44.63	LC	2012
41	09/16/88	20:32	37 51.86	9 28.92	LC	1052
			Meddy Survey			
42	09/17/88	13:49	36 04.55	9 21.35	LC	1614
43	09/17/88	16:02	36 04.36	9 11.56	LC	1804
44	09/17/88	17:49	36 04.68	9 01.44	LC	1622
45	09/17/88	19:53	35 55.71	9 11.92	LC	1758
46	09/18/88	00:45	36 13.26	9 11.81	LC	1810
47	09/18/88	12:05	36 04.89	9 12.12	LC	1810
48	09/18/88	13:35	36 04.20	9 13.51	LC	1798
			Portuguese Mooring Location			
49	09/18/88	20:15	36 36.43	8 40.40	LC	920

Drop #	Date	Time	Latitude	Longitude	Method	Cast Depth
			Outflow Component			
			(site 1)			
50	09/21/88	12:52	35 48.48	6 12.72	LC	396
			(site 2)			
51	09/21/88	15:14	35 51.07	6 01.42	LC	404
			(site 3)			
52	09/21/88	16:32	35 52.80	5 52.96	LC	540
			(site 1)			
53	09/21/88	18:53	35 48.89	6 12.89	LC	416
			(site 4)			
54	09/21/88	21:46	35 45.94	6 20.54	LC	430
			(site 5)			
55	09/22/88	01:32	35 45.12	6 28.37	LC	492
			(site 1)			
56	09/22/88	03:35	35 48.94	6 12.66	LC	406
			(site 4)			
57	09/22/88	05:28	35 45.89	6 19.90	LC	396
			(site 5)			
58	09/22/88	06:50	35 45.47	6 28.69	LC	476
			(site 6)			
59	09/22/88	08:33	35 49.47	6 37.07	LC	534

Drop #	Date	Time	Latitude	Longitude	Method	Cast Depth (m)
			(site 7)			
60	09/22/88	10:01	35 54.09	6 30.49	LC	450
			(site 8)			
61	09/22/88	11:24	35 55.20	6 24.68	LC	330
			(site 9)			
62	09/22/88	13:42	35 45.05	6 40.30	LC	710
			Section A			
63	09/22/88	17:15	35 45.74	6 13.13	LC	264
64	09/22/88	18:00	35 49.10	6 13.70	LC	408
65	09/22/88	18:55	35 51.93	6 14.26	LC	330
66	09/22/88	19:55	35 55.22	6 12.05	LC	220
			Section B			
67	09/22/88	21:24	35 54.13	6 20.43	LC	286
68	09/22/88	22:09	35 52.10	6 20.49	LC	240
69	09/22/88	22:33	35 48.75	6 20.02	LC	360
70	09/22/88	23:31	35 45.68	6 18.78	LC	388
71	09/23/88	00:29	35 42.96	6 17.78	LC	276
			Section C			
72	09/23/88	01:57	35 37.69	6 27.12	LC	256
73	09/23/88	03:02	35 40.88	6 30.09	LC	352
74	09/23/88	03:36	35 42.58	6 30.22	LC	350
75	09/23/88	04:21	35 45.27	6 29.03	LC	486
76	09/23/88	05:27	35 46.82	6 28.86	LC	444
77	09/23/88	06:32	35 49.87	6 26.43	LC	390
78	09/23/88	07:45	35 51.51	6 26.98	LC	494
79	09/23/88	08:55	35 55.19	6 27.01	LC	406
80	09/23/88	10:11	35 59.63	6 22.59	LC	216
			Section D			
81	09/23/88	11:08	35 56.37	6 28.52	LC	408
82	09/23/88	12:12	35 54.16	6 29.13	LC	426
83	09/23/88	13:05	35 52.26	6 31.87	LC	526
84	09/23/88	14:00	35 50.57	6 34.48	LC	532

Drop #	Date	Time	Latitude	Longitude	Method	Cast Depth (m)
			Section D (continued)			
85	09/23/88	15:23	35 48.75	6 36.77	LC	544
86	09/23/88	16:32	35 46.66	6 39.10	LC	634
87	09/23/88	17:32	35 43.80	6 41.34	LC	610
88	09/23/88	18:31	35 40.92	6 42.89	LC	734
89	09/23/88	19:31	35 39.52	6 39.12	LC	600
90	09/23/88	20:28	35 38.85	6 34.82	LC	474
			(Station C4)			
91	09/23/88	21:53	35 45.03	6 28.73	LC	492
			Section E			
92	09/24/88	00:49	36 01.92	6 33.77	LC	376
93	09/24/88	02:08	36 00.59	6 36.71	LC	514
94	09/24/88	03:30	35 59.14	6 40.19	LC	514
95	09/24/88	04:35	35 57.25	6 43.21	LC	600
96	09/24/88	05:51	35 55.50	6 46.00	LC	698
97	09/24/88	07:05	35 54.06	6 48.48	LC	764
98	09/24/88	08:21	35 52.67	6 52.08	LC	734
99	09/24/88	09:22	35 50.18	6 55.38	LC	820
100	09/24/88	10:20	35 48.25	6 57.95	LC	946
			Section F			
101	09/24/88	16:57	36 20.50	6 42.35	LC	302
102	09/24/88	17:36	36 18.93	6 43.87	LC	380
103	09/24/88	18:21	36 17.82	6 46.60	LC	580
104	09/24/88	19:26	36 16.05	6 48.95	LC	678
105	09/24/88	20:25	36 14.75	6 52.04	LC	728
106	09/24/88	21:20	36 12.51	6 54.25	LC	688
107	09/24/88	22:37	36 10.76	6 57.54	LC	740
108	09/25/88	00:19	36 09.15	7 00.67	LC	738
109	09/25/88	01:27	36 07.68	7 04.50	LC	746
110	09/25/88	02:40	36 06.23	7 07.64	LC	758
111	09/25/88	03:41	36 04.64	7 08.98	LC	778
112	09/25/88	04:46	36 02.63	7 12.12	LC	822
			Section G			
113	09/25/88	07:41	35 59.91	7 39.62	LC	1252
114	09/25/88	09:11	36 04.22	7 36.32	LC	1028
115	09/25/88	10:38	36 08.97	7 32.25	LC	1016

Drop #	Date	Time	Latitude	Longitude	Method	Cast Depth (m)
			Section G (continued)			
116	09/25/88	11:57	36 13.38	7 29.10	LC	846
117	09/25/88	13:15	36 17.74	7 26.45	LC	710
118	09/25/88	14:27	36 22.77	7 20.83	LC	806
119	09/25/88	15:32	36 26.82	7 18.49	LC	666
120	09/25/88	16:32	36 30.79	7 14.43	LC	564
121	09/25/88	17:36	36 35.56	7 08.65	LC	508
122	09/25/88	18:35	36 40.86	7 08.08	LC	486
123	09/25/88	19:36	36 45.41	7 05.15	LC	352
124	09/25/88	20:27	36 50.20	7 02.06	LC	108
			Section H			
125	09/26/88	00:42	36 49.04	7 59.81	LC	470
126	09/26/88	01:56	36 42.36	8 00.02	LC	730
127	09/26/88	02:57	36 37.99	7 59.99	LC	758
128	09/26/88	04:05	36 33.02	8 00.61	LC	776
129	09/26/88	05:06	36 28.13	8 01.31	LC	880
130	09/26/88	06:27	36 22.72	8 00.10	LC	1240
131	09/26/88	07:43	36 17.71	7 59.63	LC	1186
132	09/26/88	09:08	36 13.12	8 00.05	LC	1468
133	09/26/88	10:54	36 07.77	8 00.55	LC	1656
134	09/26/88	12:04	36 02.99	7 59.50	LC	1490
135	09/26/88	14:09	35 53.32	8 00.83	LC	1782
			Section FE			
136	09/26/88	18:52	35 57.88	7 09.42	LC	984
137	09/26/88	21:02	35 54.78	7 05.65	LC	956
138	09/26/88	22:24	35 50.03	6 59.87	LC	1006
			Section I			
139	09/27/88	07:40	36 00.94	5 16.99	LC	852
140	09/27/88	09:29	35 59.37	5 22.50	LC	924
141	09/27/88	11:24	35 57.97	5 29.55	LC	872
142	09/27/88	12:13	35 56.44	5 34.67	LC	514
143	09/27/88	13:24	35 56.14	5 41.64	LC	458
144	09/27/88	14:10	35 55.36	5 44.75	LC	256
145	09/27/88	15:33	35 52.96	5 52.16	LC	432
146	09/27/88	16:54	35 50.70	6 00.64	LC	316
147	09/27/88	18:11	35 49.51	6 05.97	LC	398
148	09/27/88	19:23	35 49.11	6 11.72	LC	404

APPENDIX E

Oceanus Cruise 202
XDP Log

Drop #	Date	Time	Latitude	Longitude	Method	Comment
				(site 2)		
801	09/21/88	15:48	35 51.41	6 00.84	LC	
				(site 3)		
1030	09/21/88	17:14	35 53.36	5 52.35	LC	
				(site 1)		
1040	09/21/88	19:38	35 49.05	6 12.88	LC	
				(site 4)		
1033	09/21/88	22:25	35 46.17	6 20.76	LC	bad
1035	09/21/88	22:31	35 46.33	6 20.65	LC	
				(site 5)		
808	09/22/88	02:13	35 45.54	6 28.63	LC	
				(site 1)		
701	09/22/88	04:04	35 49.13	6 12.79	LC	receiver failure
803	09/22/88	04:29	35 49.11	6 12.51	LC	
				(site 4)		
709	09/22/88	05:58	35 46.11	6 20.43	LC	
				(site 5)		
707	09/22/88	07:42	35 45.49	6 29.79	LC	
				(site 6)		
807	09/22/88	09:11	35 49.87	6 37.52	LC	
				(site 7)		
809	09/22/88	10:37	35 53.85	6 30.41	LC	

Drop #	Date	Time	Latitude	Longitude	Method	Comment
				(site 8)		
1032	09/22/88	12:09	35 54.24	6 24.56	LC	
				(site 9)		
702	09/22/88	14:21	35 45.46	6 40.73	LC	
				Section A		
1025	09/22/88	17:36	35 45.73	6 13.47	LC	
1034	09/22/88	18:27	35 49.31	6 13.77	LC	
1022	09/22/88	19:21	35 51.56	6 14.51	LC	
1046	09/22/88	20:17	35 55.13	6 12.67	LC	
				Section B		
1043	09/22/88	23:01	35 48.82	6 19.60	LC	
1051	09/23/88	00:05	35 45.58	6 18.34	LC	
				Section C		
1045	09/23/88	04:47	35 44.98	6 29.57	LC	wire broke
704	09/23/88	05:00	35 44.58	6 30.05	LC	
815	09/23/88	05:56	35 46.47	6 29.33	LC	
1058	09/23/88	06:56	35 49.49	6 27.05	LC	wire broke
1018	09/23/88	06:58	35 49.41	6 27.15	LC	
1038	09/23/88	08:13	35 50.98	6 27.39	LC	
1053	09/23/88	09:19	35 54.52	6 27.27	LC	
1039	09/23/88	09:22	35 54.30	6 27.41	LC	
				Section D		
813	09/23/88	13:40	35 51.67	6 32.35	LC	
810	09/23/88	14:32	35 50.17	6 34.93	LC	
1050	09/23/88	15:00	35 50.09	6 34.23	LC	
999	09/23/88	15:57	35 48.65	6 37.31	LC	
806	09/23/88	16:10	35 48.51	6 37.65	LC	

Drop #	Date	Time	Latitude	Longitude	Method	Comment
			(Station C4)			
1049	09/23/88	22:31	35 44.57	6 29.94	LC	
804	09/23/88	22:48	35 44.50	6 30.21	LC	
			Section E			
1044	09/24/88	01:43	36 01.24	6 33.09	LC	
814	09/24/88	02:57	36 00.41	6 37.19	LC	wire broke
705	09/24/88	03:08	36 00.10	6 37.92	LC	
824	09/24/88	04:08	35 59.22	6 40.53	LC	broken wire near bottom
812	09/24/88	05:16	35 57.58	6 43.68	LC	
828	09/24/88	06:34	35 55.77	6 46.34	LC	
711	09/24/88	07:49	35 54.53	6 48.69	LC	
			Section F			
826	09/24/88	18:05	36 18.50	6 44.69	LC	
817	09/24/88	22:02	36 12.43	6 55.13	LC	
827	09/24/88	23:25	36 10.83	6 58.09	LC	
830	09/24/88	23:30	36 10.76	6 58.50	LC	
			Section FE			
829	09/27/88	02:12	35 45.91	6 28.98	LC	
			Section I			
1048	09/27/88	08:26	36 01.02	5 17.74	LC	
1061	09/27/88	10:25	35 59.16	5 23.45	LC	
1056	09/27/88	11:40	35 57.87	5 29.98	LC	
1062	09/27/88	12:44	35 56.24	5 35.52	LC	
1057	09/27/88	12:54	35 56.25	5 36.40	LC	
1071	09/27/88	13:50	35 56.29	5 42.51	LC	
1054	09/27/88	14:29	35 55.38	5 45.16	LC	
1063	09/27/88	14:35	35 55.48	5 45.14	LC	
1055	09/27/88	17:23	35 51.19	5 59.52	LC	
1072	09/27/88	19:58	35 49.15	6 11.27	LC	

Drop #	Date	Time	Latitude	Longitude	Method	Comment
				(Station B8)		
1059	09/27/88	20:59	35 48.82	6 20.37	LC	
				(Station C4)		
821	09/27/88	21:51	35 45.29	6 29.16	LC	
1060	09/27/88	21:54	35 45.35	6 29.15	LC	
				(Station D6)		
1065	09/27/88	22:40	35 51.53	6 34.91	LC	

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No 0704-0188

1a REPORT SECURITY CLASSIFICATION
Unclassified

1b RESTRICTIVE MARKINGS

2a SECURITY CLASSIFICATION AUTHORITY

2b DECLASSIFICATION / DOWNGRADING SCHEDULE

3 DISTRIBUTION / AVAILABILITY OF REPORT
Distribution unlimited

4 PERFORMING ORGANIZATION REPORT NUMBER(S)
APL-UW TR 8914

5 MONITORING ORGANIZATION REPORT NUMBER(S)

6a NAME OF PERFORMING ORGANIZATION
Applied Physics Laboratory
University of Washington

6b OFFICE SYMBOL *(If applicable)*

7a NAME OF MONITORING ORGANIZATION
Office of Naval Research
(Code 1122PO)

6c ADDRESS *(City, State, and ZIP Code)*
1013 N.E. 40th Street
Seattle, WA 98105

7b ADDRESS *(City, State, and ZIP Code)*
800 North Quincy Street
Arlington, VA 22217-5000

8a NAME OF FUNDING / SPONSORING ORGANIZATION
Office of Naval Research

8b OFFICE SYMBOL *(If applicable)*

9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
N00014-87-K-0004

8c ADDRESS *(City, State, and ZIP Code)*
800 North Quincy Street
Arlington, Virginia 22217-5000

10 SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO	PROJECT NO	TASK NO	WORK UNIT ACCESSION NO
422PO	-	-	06

11 TITLE *(Include Security Classification)*
The Gulf of Cadiz Expedition: R/V Oceanus Cruise 202

12 PERSONAL AUTHOR(S) Maureen A. Kennelly, John H. Dunlap, Thomas B. Sanford, Eric L. Kunze, Mark D. Prater, and Robert G. Drever

13a TYPE OF REPORT
Cruise

13b TIME COVERED
FROM 9/88 TO 9/88

14 DATE OF REPORT *(Year, Month, Day)*
April 1989

15 PAGE COUNT
115

16 SUPPLEMENTARY NOTATION

17 COSATI CODES

FIELD	GROUP	SUB-GROUP
08	03	

18 SUBJECT TERMS *(Continue on reverse if necessary and identify by block number)*
Meddy — Gulf of Cadiz
Ampere Seamount — Mediterranean outflow

19 ABSTRACT *(Continue on reverse if necessary and identify by block number)*

Velocity, hydrographic, and dissipation measurements were made in the Gulf of Cadiz from 4-28 September 1988 to observe the vortices shed in the wake of Ampere Seamount, to survey eddies formed by the Mediterranean outflow near Cape St. Vincent, and to study the structure and dynamics of the outflow plume west of the Strait of Gibraltar. The expedition, the instrument systems, and their deployments are described, and preliminary results are presented. Keywords: Mediterranean outflow eddies (Meddies); Iberian Peninsula gulfs, Seawater flow, Seamount wake vortices, Oceanographic data; Fluid mechanics eddies. (edc)

20 DISTRIBUTION / AVAILABILITY OF ABSTRACT
☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT ☐ DTIC USERS

21 ABSTRACT SECURITY CLASSIFICATION
Unclassified

22a NAME OF RESPONSIBLE INDIVIDUAL
David Evans and Alan Brandt

22b TELEPHONE *(Include Area Code)*
(202) 696-4441

22c OFFICE SYMBOL

DD Form 1473, JUN 86 — Previous editions are obsolete — SECURITY CLASSIFICATION OF THIS PAGE

S/N 0102-LF-014-6603

UNCLASSIFIED